UNDERSTANDING THE OPPORTUNITIES AND CHALLENGES OF COMPLIANCE TO SAFE BUILDING CODES FOR DISASTER RESILIENCE IN SOUTH ASIA

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Project Overview

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Project Summary

This project explores the opportunities and challenges compliance to safe building codes in the current contexts of Bangladesh and Nepal, to achieve increased disaster resilience. Recent disasters in both countries highlight that non-compliance to building codes is one of the significant causes of building-related disasters in South Asia. Increased institutional and community awareness to the importance of safe building codes presents an opportunity to explore barriers and enablers to compliance. Building codes do exist in the two countries, but compliance is generally lacking or limited, especially in the widespread informal building sector. The informal building sector engages in construction which lacks code compliance due to a deficiency in the understanding of or limited access to the codes and/or economic pressures. The project was approached in two stages. Stage 1 involves a comprehensive literature review to identify potential solutions and gaps in terms of disaster resilience. Stage 2 reports on the results of semi-structured interviews and focus group discussions enabling stakeholders to identify a range of challenges and opportunities for facilitating voluntary compliance to safe building codes. The outcomes of the stages are then combined to address the need for understanding how building codes might be more widely adopted to enable disaster resilience.

Keywords: disaster resilience, safe building codes, grey building codes, building code compliance.

Project outputs and outcomes

The project had the following key outputs:

- Global literature review on building codes and disaster resilience.
- Local literature reviews on building codes and disaster resilience in Bangladesh and Nepal.
- An extensive bibliography on literature relevant to the project’s topic.
- Three consultative and experiencing-sharing workshops in Bangladesh and Nepal attended by project collaborators and research assistants, as well as key local stakeholders and policymakers.
- Consultations with a wide range of local stakeholders in Bangladesh and Nepal, allowing collection of data for the project.
- “Grey Building Handbook” for low-income, informal sector builders, which can be utilised as an illustrated training manual.
• Translated versions of the “Grey Building Handbook” in Bengali and Nepali, the languages of the project countries.
• A video on the project highlighting and illustrating its key aspects.
• A project website portal through the CIFAL Newcastle website.
• A journal paper based on the project (see Ahmed et al., 2018 in the references). Other journal papers are being developed for future publication.

All these outputs have been featured or incorporated within this report.

For a project such as this, most of the outcomes become evident over a period of time, particularly the utilisation of the “Grey Building Handbook” for local level capacity building, and dissemination of the project report to policymakers and stakeholders to improve their work in this field. After project completion, the project video will be uploaded on YouTube and other social media outlets, which will allow understanding its outcome in terms of audience viewing and appreciation. Some of the key outcomes evident in the short term include:

• Capacity building of a number of early career researchers who had very little or no experience in research projects of this nature and scope, which can be expected to contribute to their future research and professional work.
• Inter- and intra-country linkages between universities and researchers, who were not known to each other before – an outcome in terms of forging long-term connections for possible future partnerships and collaborations, both locally and regionally.
• Connections were established with key policymaking institutions in the two project countries, namely RAJUK (Dhaka City Development Authority), Bangladesh, and Ministry of Urban Development, Nepal, both key actors in the field of building codes. Their active interest and engagement in the project workshops indicate potential for them to espouse the project’s approach to voluntary compliance in their institutions.

Potential for further work

This project pointed to further research directions to broaden the understanding of the multi-faceted topic of building codes compliance, which includes:

• Developing options for retrofitting or strengthening old buildings, following to the extent possible the construction standards as prescribed in the building codes of the respective project countries.
• Stakeholder and policy mapping for better understanding of possible roles in the integration of building codes and building regulations.
• Exploration of community perceptions of risk and willingness for voluntary compliance, and the incentives and policy environment required for it.
• Developing methods of raising public awareness and the channels and stakeholders that might be effectively involved for that purpose.
• Understanding the role of social media in how it might be utilised to promote widespread compliance to building codes and regulations.
Investigation of the role of the private sector, and how effective partnerships can be forged between the public and private sectors, and civil society.

Publications

Pull quote
“Safe buildings can save lives; tragedies that we have seen in these countries in the recent past need not happen. What is required are building codes that are appropriate and affordable for the vast majority of low-income people in South Asian countries.”


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All photographs are by Dr Iftekhar Ahmed unless stated otherwise.
Figure 2. Construction site, Nepal
1. Introduction

1. Project Summary

The intent of this project was to explore the opportunities and challenges of how compliance to voluntary safe building codes can be facilitated in the current contexts of Bangladesh and Nepal (Figures 1 and 2) for increased disaster resilience in South Asia, focusing on two countries of the region: Bangladesh and Nepal. Recent disasters in both countries highlighted that one of the significant causes of the problem lies in non-compliance to building codes. Such disasters have brought institutional and community awareness of the importance of safe building codes, presenting an opportunity to explore barriers and enablers to compliance. Building codes do exist in the two countries, but compliance is generally lacking or limited, especially in the widespread informal building sector. The informal building sector engages in construction which lacks code compliance due to a deficiency in the understanding of or limited access to the codes and/or economic pressures. Thus this project addressed the need for understanding how these codes might be more widely adopted to enable disaster resilience.

Collaboration between four universities; The University of Newcastle, Australia, University of Dhaka, Bangladesh, BRAC University, Bangladesh and Tribhuvan University, Nepal focused on four significant areas:

[1] Sharing the understanding that evidence-based knowledge is a critical component in the commitment to local action

[2] Institutional and community awareness of the importance of compliance with/barriers to enforcement of codes


[4] Subsequent development of local and international dissemination networks
Figure 3. Rapidly urbanising contexts of Nepal (above) and Bangladesh (below) with very limited compliance to building codes and regulations.
2. Project description

a. Research problem

The generation of scientific knowledge on building and construction continues globally, however the application to disaster risk reduction remains limited. In low-income countries within South Asia specifically, building code frameworks are generally inadequate, reflecting the situation in the case study countries selected for this project – Bangladesh and Nepal. The bulk of buildings in these countries are constructed informally without adherence to building codes and rough estimates indicate that well over 80 percent of housing in these low-income South Asian countries is built using informal construction (UN-HABITAT, 2010; World Bank, 2007). There is very little or no application of building codes in informal sector construction. Even in the very small proportion of formal sector housing, adherence to building codes is generally lacking or limited at best (see Figure 3). Unlike procedures in developed countries, building codes are not well-integrated into building and planning regulations in these low-income countries. Both Bangladesh and Nepal have building codes (DUDBC, 2005; HBRI, 2015), but enforcement and compliance face significant challenges and the codes serve mainly as good practice guidelines. Ultimately, the responsibility for compliance is up to professionals, builders or authorities to follow them.

It is understandable that developing countries such as Bangladesh and Nepal would face constraints in implementing building codes. Beyond the oft-cited issues of enforcement and corruption, affordability is a key constraint for the vast bulk of the population that builds informally. The codes provide good practice guidelines often based on developed country models and can thus be onerous and difficult to implement in the socio-economic context of South Asia. The codes also include guidelines for safety to enable buildings to be disaster resilient – these hazard-related codes can be termed as ‘safe building codes’ to differentiate them from codes that deal with other aspects of construction (see for example, Library of Congress, 2015). At a bare minimum, if only the safe building codes are followed, a level of disaster resilience can be achieved. To support this process, a ‘grey’ document or guidance handbook is required, locally contextualised and achievable within the socio-economic constraints of developing countries: a key output of this project. The handbook produced as part of this project includes a set of options to meet varying economic and environmental conditions, and extensively uses visual material for ease of comprehension and communication. The handbook has been translated to Bengali and Nepali for effective local dissemination.

Both Bangladesh and Nepal face disaster risk from various types of hazards including earthquakes, floods, windstorms and landslides. Nepal endured severe earthquakes recently in 2015 (Amos, 2015), where the common adage “Earthquakes don’t kill people, buildings do” (Stockton, 2015; UNOPS, 2013) was visibly and tragically apparent. Although Bangladesh has not experienced a major earthquake in recent times, strong tremors often occur, creating public fear (Hannam, 2016; USGS 2012; The Daily Star, 2016); a massive earthquake is a real and significant possibility (Hays, 2016). Bangladesh is also frequently affected by floods and cyclones, for example recently in 2016 by Cyclone Roanu (Australian Broadcasting Corporation, 2016a). Both these countries are also severely threatened by climate change with increasing magnitude and frequency of hazards including new types of hazards such as extreme heat and cloudbursts, likely to exacerbate the impact of disasters. This is a significant global change issue. While earthquakes are not linked to climate change unlike hydro-meteorological disasters (e.g. floods, cyclones), their impacts experienced particularly in cities in a rapidly urbanising world have implications for global change (see for example ESSP, 2006; Steffen et al., 2004). The interpretation of global change aligns with APN’s definition as outlined in its 4th Strategic Plan that urban disasters are “human induced processes” and in an increasingly urban
Disasters exact a severe toll on buildings; in addition to damage and loss of assets in countries that can barely afford them, loss of human lives is most tragic and irreparable. The avoidance of building regulations and the lack of adherence to building codes mean that it does not always require a hazard to result in a disaster – the collapse of the Rana Plaza garment factory in Bangladesh in 2013, killing more than 1,100 people—mainly female garment workers—and injuring another 2,500, illustrates this point (IGLHR, 2014). Such human-induced disasters, often a result of rapid and unplanned urbanisation linked to globalisation, is again a global change issue. Indeed, increasing risk to disasters and climate change impacts is a key aspect of contemporary global change, which this research project explores through the topic of building codes for disaster resilience.

The devastating, and high-profile, disasters mentioned above including the Nepal earthquakes and Bangladesh building collapse have raised local awareness on the importance of safe buildings. They have spurred significant institutional and community interest and activity in both these countries on disaster resilient construction and safe building codes, in the face of public fear and anxiety, as discussed later in the case studies (Chapters 3 and 4). It does appear that there might be an opportunity for voluntary compliance to safe building codes beyond the necessity of policing and institutional enforcement. It is reported in the case studies that some municipalities in Nepal and some real estate developers in Bangladesh are voluntarily following building codes, representing a gradual paradigm shift. It was therefore a relevant and opportune time to undertake this project with the purpose of exploring the research problem relating to understanding the opportunities and challenges of facilitating compliance to safe building codes.

b. Research questions

Given the widespread lack of compliance to building codes in the case study countries of Bangladesh and Nepal and consequent disaster impacts leading to a growth of interest in safe building codes, a key exploratory research question and sub-questions were identified.

Key Research Question:

**How can compliance to voluntary safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased disaster resilience?**
The following Sub-questions - were framed to deliver an answer to the main research question:

- **What are the strengths and weaknesses in terms of disaster resilience of building codes globally, and specifically in the project countries?**

- **What knowledge and insights can be gained from institutional and community stakeholders in the project countries on opportunities and challenges for facilitating compliance to safe building codes?**

- **What practice-and-policy guidelines are required to facilitate voluntary compliance and implementation of safe building codes?**

The research problem is complex, multi-faceted and deeply entrenched in socio-economic, political and cultural conditions and has taken root over a long period of time. To address these issues would require social transformation of a profound nature, and at this point in time perhaps only the small beginnings of such transformation are evident. The research therefore does not provide quick-fix and easy solutions, but identifies a probable and plausible trajectory for the small beginnings of social transformation that may realise a greater and more widespread voluntary compliance of safe building codes over the long term.

c. **Rationale for context focus**

Within the Asia-Pacific region, South Asia stands out in terms of low economic and human development; after Sub-Saharan Africa, it is the least developed region in the world (UNDP, 2015; World Bank, 2016). The region is also highly vulnerable to disasters (Gaiha et al., 2010). A quarter of the world’s population live in South Asia (World Bank, 2016) and it is one of the most densely populated regions of the world, compounding the significance of undertaking research in this region.

The impacts of disasters in the smaller South Asian countries are pronounced and recovery difficult because of their lower socio-economic development compared to the largest South Asian country, India (Sarma, 2015). The scope of this research project is focused on some of the smaller South Asian countries, namely Bangladesh and Nepal, but offers lessons relevant to the wider region. Transfer of lessons and cross-learning can be achieved between these countries due to the great extent of similarity in socio-economic conditions. Some of these countries including Bangladesh and Nepal are disaster hotspots and recent events have instigated an interest in safe building codes, therefore allowing cross-learning between nations to achieve disaster resilience.
d. Objectives

- Review global and local literature in the project countries including building codes and regulations to identify potential opportunities and gaps in terms of disaster resilience;
- Engage in consultations with key stakeholders at institutional and community levels to understand challenges and opportunities for facilitating voluntary compliance to safe building codes;
- Produce practice-and-policy guidelines for facilitating voluntary compliance and implementation of safe building codes extending to informal sector buildings;
- Involve early career researchers in the project countries to meet the above objectives and thereby build local research capacity;
- Explore possibilities of forming networks and cross-learning between the project countries and wider regional and international knowledge dissemination.

3. Methodology

The methodology employed a qualitative exploratory research design, linked to the main research question:

*How can compliance to voluntary safe building codes be facilitated in the current contexts of Nepal and Bangladesh for increased disaster resilience?*

To answer this question a qualitative exploratory methodology was adopted as it assists to “develop as thick and rich as complete an account of the phenomenon under investigation” (Quinlan, 2011, p. 420). The intent of this research is well aligned with such an approach given it explores the subjective experiences and realities of specialist practitioners to understand the phenomenon.

The research methodology was approached in two stages with the intent to understanding safer building codes adoption in two South Asian countries, Bangladesh and Nepal:

**Stage 1** involved development of a comprehensive literature review. Both academic and grey literatures were reviewed to identify potential solutions and gaps in terms of disaster resilience.

**Stage 2** involved semi-structured interviews and focus group discussions to identify a range of challenges and opportunities for facilitating voluntary compliance to safe building codes.

To seek answers to the main research question, a set of descriptive sub-questions were posed allowing discovery of the nature and characteristics of the phenomenon explored by the main research question. The descriptive studies employed a range of empirical methods including case studies, interviews, focus group discussions and project workshops, utilising participatory and consultative data collection tools. The stakeholder consultations in the project countries and project workshops were prime vehicles for employing these methods and tools.

The empirical stage of the project was substantial, and informed and complemented by literature reviews at different levels including global and local. Because of the exploratory nature of the research, the global literature review was also exploratory and cast a wide net to capture inter- and transdisciplinary perspectives. However, the specific nature of the project with its focus on the built environment and disaster resilience allowed defining the boundaries of the literature review. At the
local level, the literature reviews were more focused on the specific topic of building codes in the project country contexts.

**Activities undertaken**

The project consisted of the following key activities to achieve the project outcomes:

- At the project outset, the University of Newcastle (UoN) team in Australia undertook a global literature review. Although focusing on the developing world context, the review also examined the challenges encountered and strategies adopted to integrate building codes into the regulatory framework more widely, particularly safe building codes. The global literature review is included in this report in Chapter 2.

- Concurrently, the project partners – University of Dhaka (DU) and BRAC University (BU) in Bangladesh and Tribhuvan University (TU) in Nepal – built up a local database of literature on building codes, including national building code documents.

- The status of the above activities was presented and analysed at an ‘Introductory Workshop’ in Kathmandu, Nepal on 8-10 November 2017 (Figure 4), a project workshop allowing formulation of strategic tools for stakeholder consultations and data collection in the subsequent stages of the project (see appendix).

- The project partners undertook institutional and community stakeholder consultations and data collection in their respective countries to identify opportunities, challenges and options for promoting safe building codes, particularly in the informal building sector, using tools developed together with UoN.

- An ‘Interim Workshop’ was then held in Dhaka, Bangladesh, on 23-25 April 2018 (Figure 5). This project workshop was held to review the findings of the stakeholder consultations and data collection, identify achievements and gaps, and plan for subsequent activities (see appendix).

- Deriving from the discussions and feedback at the ‘Interim Workshop’, the project partners finalised their country reports. These reports are included in this report as case studies (see Sections 2 and 3) and informed the production of this final report.

- Based on the country reports and global literature review, a “Grey Building Handbook” was produced by the UoN team, targeted specifically for the informal building sector in the project countries. The handbook was translated into and published in Bengali and Nepali for dissemination locally in the two project countries. The handbook is included with this report as an appendix.

- A final project workshop was held in Pulchowk Campus, Institute of Engineering, Tribhuvan University, Lalitpur, Nepal on 28-30 August 2018 (Figure 6), where the findings of the project from the three countries – Australia, Bangladesh and Nepal – were presented and
reviewed, and future long-term planning was carried out. Filming was also undertaken for production of a video on the project. The first day included presentations on the three country reports, as well as the draft final report. The “Grey Building Handbook” (see appendix) was also launched, including the translated Bengali and Nepali versions. There were also high-profile presentations from the Ministry of Urban Development and the Dean, Institute of Engineering, Tribhuvan University, Nepal. The second day involved long-term planning beyond the project conclusion including publications, participation at conferences and further research collaborations. There was a field visit the third day to earthquake-devastated areas on the outskirts of Kathmandu, where reconstruction projects were ongoing, particularly the UN-Habitat supported project in the historic city of Bungamati. A regional workshop in the future to share the project’s findings was planned and support for that will be sought from the World Bank, following from preliminary communications.

- A website dedicated to the project was created through the CIFAL-Newcastle Centre for Resilience and Sustainable Development, and the project deliverables are freely available from this website for wider dissemination (see: https://www.newcastle.edu.au/about-uon/governance-and-leadership/faculties-and-schools/faculty-of-engineering-and-built-environment/cifal/projects/projects-apn). In addition, the project activities were reported on the CIFAL-Newcastle website (see appendix) and widely promoted.

- A dissemination video has been produced and will be made available on YouTube and also uploaded on the project website.


- Possibilities are being explored based on the interest indicated by the World Bank and CIFAL Newcastle to support and help run a wider regional workshop as part of a dissemination strategy and to seek future research opportunities.
Figure 4. Introductory project workshop held in November 2017 in Nepal

Figure 5. Interim project workshop held in April 2018 in Bangladesh
4. Project relevance

Relevance to APN’s Fourth Strategic Plan

The project relates to APN’s Fourth Strategic Plan (2015-2020) by promoting cooperation between APN member countries to address a serious global change issue—disaster risk—and generate benefits in terms of regional knowledge-sharing. Disaster risk is a global change issue linked to climate change and human activities altering the earth’s surface, hence relevant to APN’s mission. As discussed below, the project addressed all the four areas of APN’s Action Agenda:

- The project responded directly to one of the key areas of APN’s Research Agenda—Risk Reduction and Resilience—and focused on two low-income disaster-vulnerable countries in the Asia-Pacific, Bangladesh and Nepal. Australia is also an APN member and for this project, Australia collaborated with the other two member countries in this regional research project. Although this project focused on the specific field of the built environment, the nature of the research involved interdisciplinary collaboration between architecture, construction management, engineering, law and social sciences, and transdisciplinary collaboration by linking academia with civil society, government agencies and the private sector (e.g. real estate developers). While bearing a relationship with some of the indicative research topics in the ‘Risk Reduction and Resilience’ key area, such as revisiting current disaster risk management strategies and integrating disaster risk reduction in regional (and urban) planning, this project offers a unique research topic for APN to broaden its portfolio.

- The Capacity Development Agenda was an important element in this project in several ways. Firstly, it produced guidelines informed by safe building codes that will be applicable for training of local construction workers and informal sector builders, and more broadly of personnel from government agencies and NGOs involved in the disaster resilience field. Secondly, early career researchers were engaged in all three project countries, providing a valuable capacity building opportunity through working on this regional and international research project. Finally, the involvement of CIFAL Newcastle—with its own strong capacity development agenda—meant that the project outcomes will be utilised for wider training and exchange of learning. CIFAL is engaged in other capacity building initiatives in several countries in Asia and also in the Pacific region, therefore the findings of this project will support regional capacity building beyond the project countries. Additionally, the World Bank

![Final project workshop held in August 2018 in Nepal](image-url)
is expected to support a regional workshop to disseminate the project results, which will also promote and contribute to regional capacity building initiatives.

- In line with activities suggested by APN that meet its Science-Policy Agenda, this project sought new ways of working between technical/scientific, institutional and at-risk communities, and enhance local research and policy through a multi-country endeavour. The project activities developed knowledge to inform policy for advancing resilience, also serving as a platform for a range of stakeholders to contribute to the knowledge development process, very much in line with the examples of activities under APN’s Science-Policy Agenda. The research teams have strong connections with government institutions in both the project countries and were able to benefit from these links by including the policy community as an integral part of the research.

- In terms of APN’s Communication and Outreach Agenda, this project had a strong focus in this area overlapping with its capacity development activities. The ‘grey’ building handbook on safe building codes (see appendix) is an example of how the project related to the agenda’s overall target of producing “tailor-designed information”. The project undertook communication and outreach activities at different levels, targeting local researchers and built environment professionals, government agencies and NGOs, and informal builders and construction workers. The basic premise of regional collaboration between three APN member countries was a powerful communication and outreach initiative. Involvement of UNITAR’s CIFAL Newcastle and the World Bank’s Global Facility for Disaster Risk Reduction (GFDRR) allowed communicating the project’s outcomes to a wider regional and global audience.

Relevance to global change and sustainability

Disaster resilience is of high level policy concern in both Bangladesh and Nepal because of the frequent and various disasters that impact these countries. Bangladesh is one of the few countries in the world that has a Ministry of Disaster Management and Relief dedicated to disaster risk reduction with a key policy instrument in this regard, the ‘National Plan for Climate Change and Disaster Management (2016-2021)’ (Ahmed et al., 2015) and the ‘National Plan for Disaster Management (2016-2020)’ (MoDMR, 2016). Nepal has a Disaster Management Section in the Ministry of Home Affairs and a ‘National Strategy for Disaster Risk Management’ (NSDRM) 2009 (MoHA, UNDP & ECHO, 2008). Nepal repealed the Disaster Risk Reduction and Management Act 2017 (NDRR&M Act).

The NDRR&M Act specifically focuses on protecting public life, public and private property, natural and cultural heritages, physical properties and minimising the disaster risk which shows the importance of building codes for disaster risk reduction, thus this present research project has potential for informing national policy. However, in Bangladesh the issue of building codes is dealt with by the Capital Development Authority (RAJUK) under the Ministry of Housing and Public Works, and although there are recent concerns in Bangladesh regarding building codes for disaster resilience, the building codes are not coordinated with the national disaster management policy. There is thus the possibility of facilitating coordination between policies for disaster risk reduction and safe building practice. In terms of safe building codes, both governments of Bangladesh and Nepal require significant and extensive inputs to translate their policy instruments in practice particularly to address the widespread informal sector and addressing potential disaster impacts and resilience strategies for
at-risk communities. Thus, the timing and scope of this project is relevant to both country contexts as policymakers and national institutions are faced with the challenges of implementing, mainstreaming and rolling out nationwide policy processes. The project is also opportune because of recent commitments made by both countries to the global Sendai Framework for Disaster Risk Reduction (2015-2030).

In the UN’s Sustainable Development Goals, disaster risk reduction is emphasised, particularly in Goal 11 on ‘Sustainable Cities and Communities’, where clearly the link between disaster risk reduction and sustainable development is articulated (UN, 2015). For any developmental initiative to be sustainable, investments into resources, assets and institutional and community capacity need to be safeguarded, so that disasters do not undo the progress made by the initiative. The processes of sustainable development and disaster risk reduction are inextricably linked. This project was founded on this premise.

Furthermore, the project aligns with the views of key global change programs such as ESSP (2006) and IGBP (Steffen et al., 2004), involving a range of human activities, in addition to anthropogenic climate change—such as urbanisation and land-use patterns—that are altering the earth’s systems. These anthropogenic changes lead to disaster risk, requiring resilience to withstand and adapt. Additionally, the project relates to the UN’s global agendas including the Sendai Framework for Disaster Risk Reduction and Sustainable Development Goals, both promoting safe building practices. The project links with the World Bank’s global ‘Building Regulation for Resilience’ program and the disaster risk reduction mission of UNITAR’s CIFAL Newcastle, which are part of global networks.
Figure 7. Urban density, Japan
2. Results & Discussion

SECTION 1: Global overview on disasters and building codes

Nations around the world are subjected to natural hazards that vary in magnitude and nature and unfortunately, the incidence of devastating disasters is increasing (Hillier & Nightingale, 2013). In the last decade alone, more than 6300 disaster events were recorded with approximately fifty percent transpiring in Asia (IFRC, 2015; ADRC, 2016), a region with multiple developing countries where disaster impacts are often severe (Ahmed et al., 2018).

Scientific evidence has shown the link between climate change and the increasing frequency, intensity and magnitude of extreme weather-related disasters (Intergovernmental Panel on Climate Change, 2012). However, climate change extends to a wider range of human activities that are altering the earth and its ecosystems, including land-use change and urbanisation (Steffen et al., 2004) (Figure 7), subsequently increasing vulnerability to disasters particularly in regions with ineffective land use planning systems (GFDRR, 2015).

Earthquakes provide a key example: while the causes of earthquakes may be natural, their impacts are more significant across human built environments particularly where compliance to safe building codes is lacking (UNISDR, 2010). Similarly, massive migration and congestion of urban centres often occurs without corresponding urban planning regulations, which compound these impacts (GFDRR, 2015). Ultimately, the outcome of many disaster events can be traced to societal decisions in relation to land use planning and building systems: development location and construction techniques. Conversely, building and planning regulations are considered a powerful tool in the attempt to increasing community resilience and reducing risk in relation to disaster events (Bernicat, 2015; World Bank, 2015).

e. Promoting change

Due to global concern regarding the increase in environmental hazards, nations around the world have come together under various international platforms to find collective ways of solving the problems faced in the built environment and other sectors. Agreements made on such a level are adopted and contextualised to adapt to the unique needs of countries and their communities. The United Nations (UN) has been at the frontline of major global decisions and since the 1990s has focused on disaster risk reduction (DRR) when it declared the 1990s as the International Decade for Natural Disaster Reduction (JICA, 2017). Subsequently, the UN developed several strategies for DRR with the Hyogo Framework for Action 2005 (HFA), considered one of the first major international accords to demonstrate an ongoing commitment to this area (UNISDR, 2007). The HFA has since been superseded by a more robust global commitment and a 15-year plan of action: the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015a). The Sendai Framework, within its wider global resilience agenda, clearly articulates the importance of safe building codes and within its Priority 2 entitled “Strengthening disaster risk governance”, it states:

“To encourage the establishment of necessary mechanisms and incentives to ensure high levels of compliance with the existing safety-enhancing provisions of sectoral laws and regulations, including those addressing land use and urban planning, building codes, environmental and resource management and health and safety standards, and update them, where needed, to ensure an adequate focus on disaster risk management” (UNISDR, 2015a, p. 12).

Recently, the international commitment has been further shown through the United Nations Sustainable Development Goals (SDGs) (United Nations, 2015). The SDGs identify targets that recognise the importance of DRR (UNISDR, 2015b). One such target is to support least developed
countries - through financial and technical assistance – to construct sustainable and resilient buildings utilising local materials (UNISDR, 2015b) in which building codes may be a mechanism to assist in achieving this target.

Other global strategies run in tandem to the abovementioned, and importantly, further highlight the need to address the complex and fragmented system of planning and building code compliance. As an example, the ‘Resilient Cities Campaign’, managed through the United Nations Office of Disaster Risk Reduction (2010), has identified that for earthquake events, poorly built buildings are unable to withstand seismic shocks, are more prone to collapse and result in most deaths. Similarly, poor construction combined with unsuitable development locations exposes communities to the full force of many natural hazards including tsunami, cyclone and flood events (UNISDR, 2010). In this manner, UNISDR stated that a key element to building resilient cities is to: “Apply and enforce realistic, risk compliant building regulations and land-use planning principles” (UNISDR, 2010, p. 8).

Along with the UN, prominent international development agencies such as the World Bank, United States Agency for International Development (USAID) and Japan International Cooperation Agency (JICA) have also attempted to address the global priority of resilient buildings and are promoting the uptake, compliance and implementation of safe building codes (JICA, 2016; USAID, 2016; World Bank, 2015). As the GFDRR (2016) aptly states: “Building code compliance saves lives” (p. 2).

5. Building codes

f. Origins of building codes

The Code of Hammurabi is considered one of the earliest records that refer to building law (Encyclopaedia Britannica, 2018). Established by King Hammurabi (1792-1750 BCE) of Babylon, the laws made reference to construction with provision for remuneration of builders and their liability in case of damages and collapse. The laws—considered rather barbarous today—require, for example, that the builder or his son be executed if a building collapses and kills the owner or his son (Johns, 1903). Other literature sources trace the origin of building codes to the Great Fire of Rome around 64 A.D. (Cote & Grant, 1988). The Roman Empire had undergone rapid development which led to increased construction including apartment buildings with little attention being paid to the quality of construction and the materials used. The fire was subsequently attributed to poor construction practices and this brought forth a new master plan that was, importantly, ‘enforced’ to avoid any future events (Cote & Grant, 1988; Caryl, 2014).

Although various forms of codes were adopted over the years, the Great Fire of London in 1666 introduced significant change. Following this devastating event more than 13,000 buildings were destroyed as the city was left in ruin, which was attributed to rapid fire spread from combustible construction materials. Consequently, building codes were introduced that considered fire prevention for life safety and property protection, setting a precedence for many codes today (London Fire and Emergency Planning Authority, 2018). Over the decades new codes have been introduced and existing codes amended following other major disaster events— for example the San Francisco earthquake and fire of 1906 and the Chicago fire of 1971— to aid in protecting the public (NCGBCS, 2016; Cote & Grant, 1988).
g. Defining building codes

Building codes and regulations are important for disaster risk reduction and adaptation to climate change (World Bank, 2015). Cote and Grant (1988) explain that “A code is a law or regulation that sets forth minimum requirements and, in particular, a building code is a law or regulation that sets forth minimum requirements for the design and construction of buildings and structures.” (p. 53).

Early commentary often defined building codes as the requisite provision and order needed for the construction and maintenance of buildings. Such versions of codes were mainly concerned with health and safety; however, they were gradually expanded to include a wider set of requirements as we know today (Bergeron, 2008; NCGBCS, 2016). The Australian National Construction Code (NCC) provides an example that aptly demonstrates the comprehensive nature of contemporary policy:

“The National Construction Code provides the minimum necessary requirements for safety and health; amenity and accessibility, and sustainability in the design, construction, performance and liveability of new buildings (and new building work in existing buildings) throughout Australia. It is a uniform set of technical provisions for building work and plumbing and drainage installations throughout Australia whilst allowing for variations in climate and geological or geographic conditions.” (ABCB, 2018).

Although building codes and regulations are often used simultaneously, they are significantly different in meaning and scope. The broader term ‘building regulations’ as in developed countries often refers to both land-use planning and building codes (World Bank, 2015). However, in many countries such as Australia, there is a division between building codes and regulations, where building codes relate to technical building provisions or construction requirements (ABCB, 2018) and regulations concentrating on administrative processes such as building and planning permits (see for example, New South Wales Environmental Planning and Assessment Act, 1979).

What is important is that the integration of building codes and regulations has been advantageous in minimising the impacts of disasters. Their importance as a mechanism by which to protect life and build community resilience has become the focus of countries more recently (UNESCAP, 2012). Japan provides a prime example: the country maintains some of the world’s strictest codes, yet it has taken more than seven decades, and a series of disasters, for Japan to reach this stage (Glanz & Onishi, 2011).

However, the situation is vastly different for many developing countries where building codes are often not mandatory (see for example, Thiruppugazh, 2008). Bangladesh has a National Building Code, yet it has been explained that “the Building Code is not an independent legislation or act, rather it is a national level approved document” (HBRI & BSTI, 2006). In addition, within developing countries it is widely reported that enforcement and compliance of codes face serious barriers which add further complexity, including ineffective governance and corruption (GFDRR, 2014), resulting in vulnerability to disasters.

h. Prescriptive and performance based codes

Building codes may be categorised as prescriptive or performance based. Prescriptive regulations are standards created to describe how buildings should be constructed. They specify objectives, processes and often materials required to achieve the desired regulatory goal (Cote & Grant, 1988; Gann et al., 1998). However, prescriptive regulations are generally inflexible and often impede innovation (Greenwood, 2007). Introduced to address some of the shortcomings of prescriptive regulations, performance-based codes differ as they provide a more flexible approach. Performance-based codes have objectives set out, however they offer the opportunity for innovation, creativity or consideration
of cultural and heritage value. This flexibility allows for alternative solutions to be developed to suit the individual building requirements: achieving the same regulatory goal, but through a different perspective (Cote & Grant, 1988; Gann Wang & Hawkins, 1998).

6. Disaster resilience within the informal sector

The inherent link between disasters and housing types that are more resilient has been well established (see for example, Gautam et al., 2016) where it is widely cited that disaster events present an opportunity for building future resilience (Birkmann et al., 2010; Haigh & Amaratunga, 2011; Manyena, 2013). In fact, many country-specific guidelines and initiatives for safer buildings have arisen following major disasters (Bernicat 2015; see for example ERRA, 2006; NHDA, 2005).

In the project countries, Bangladesh and Nepal, recent disasters have been triggers for institutional consideration of the importance of building code compliance. In Bangladesh after recent building disasters, particularly the collapse of the Rana Plaza garment factory in 2013 killing over 1,100 and injuring many more people (Australian Broadcasting Corporation, 2016b; IGHLHR, 2014), the Bangladesh National Building Code was reviewed and updated, and there are moves to make the policy mandatory and enforced through a new regulatory authority (HBRI, 2015). Similarly in Nepal, after the recent Gorkha earthquakes 2015 which killed over 8,790 people, 22,300 injuries and more than half a million buildings collapsed (PDNA, 2015). The national building code (NBC) of Nepal is in a review process and the government declared NBC mandatory and made the local governments responsible for enforcement.

However, a large proportion of buildings continue to be constructed informally without permits; therefore, the application and regulation of codes is not enforced. Within many developing countries, built-up urban centres and peri-urban areas are often associated with large informal settlements. Dobson, Nyamweru, & Dodman (2015) highlight that globally, a large percentage of the most vulnerable populations live in informal settlements. These communities are often home to the urban poor and their circumstances leave them vulnerable and exposed to various hazards (Prayoga & Imtiaz, 2017).

Housing development within the informal sector often consists of uncoordinated construction processes, erratic development patterns, and can exist on environmentally vulnerable land, or often on vacant private land that lacks legal title (Fernandes, 2011). Fernandes (2011) argues that building development in the informal sector are the results of long existing traditional processes and practices of land acquisition, tenure and building. Furthermore, there is a growing realisation that regularisation rather than eviction is the right approach to ensuring safety within these communities. To increase disaster resilience a different approach is also required for ensuring safety and capacity building within this context. The extension of lessons from building code compliance in the formal sector to the informal sector context has been identified as a positive move in the safe building codes agenda (Fernandes, 2011).

i. The importance of traditional knowledge

Human interaction with the physical and social environment over the years has formed the basis and foundation of traditional knowledge (Zhang, 2015). Traditional buildings—buildings constructed based on customary knowledge and expertise—constitute a large portion of structures in developing countries. Their prevalence is due to cost effectiveness of traditional construction and also the promotion of local skills, culture and native materials (see for example Gautam et al., 2016).
According to Fujieda & Kobayashi (2013), the growing interest in the use of indigenous knowledge in construction further facilitates resilience and independence of vulnerable communities.

It must be acknowledged that the informal sector is not totally devoid of rules and processes for development, but the absence of the formal procedures of conventional development is what constitutes the informality. Khalafzai & Nawaz (2017) claim that “Unequal power dynamics between western science and TK [traditional knowledge] have undermined the potential role that traditional knowledge-holders can play as active participants in many fields including DRR” (p.39).

Fortunately, the current advocacy to recognise the knowledge and expertise of indigenous people in planning reinforces social rights and justice, and assists creating resilience (Fernandes, 2011). According to the Asian Development Bank (2013), finding a middle ground in the establishment and enforcement of building codes through a participatory approach gives higher certainty of achieving the desired results. In many ways this is aligned with the term ’procedural justice’ as conceptualised by Murphy (2017) which encourages willingness to comply with regulations due to identification with the authority and reduced negative sensitivities.

7. Building code compliance

According to Le Grand (2005), “Compliance is the act of following the rules” (p. 2), it is the level of adherence to the law (Australian Government, 2013). The concept of compliance is not limited to the development and enforcement of regulations, but a social transformation where organisations and communities appreciate the benefits of safe codes and follow them willingly: aptly termed by Johnson (2011) as a “compliance culture” (p. 27). In other terms, compliance is centred on the premise that people are inspired to do the right thing and/or follow stipulated rules for personal gain through thorough assessment of possible penalty and consequences for non-compliance (Murphy, 2017).

According to Burby and May (2000), two major and conflicting philosophies address the issue of compliance; the use of deterrence and facilitation. The deterrence approach includes frequent inspection and severe sanctions involving financial penalties for non-compliance. While facilitation involves more of a flexible and collaborative approach to compliance and involves incentives and technical assistance (Burby and May, 2000).

Burby and May (2000) explain that “The general idea here is that by lowering the costs of compliance (i.e. facilitating compliance) and by rewarding good behaviour while reserving punishment for recalcitrant ‘bad apples’ who consistently violate code requirements, a regulatory climate will be created that fosters voluntary compliance” (p. 3). These forms of compliance have also been categorised as: enforced compliance, deterrence, and voluntary compliance (Australian Government, 2013).

j. Types of compliance

Enforced compliance

Enforcement is quite simply undertaking government activities that compel adherence to regulatory requirements (Australian Government, 2013). Enforcement activities may involve:

1. Inspections
2. Fines
**Deterrence**

Deterrence is aligned with enforcement; however, it relates to “the act or process of discouraging actions or preventing occurrences by instilling fear or doubt or anxiety” (Australian Government, 2013, p. 8). This form of compliance includes:

1. Increasing the likelihood of exposing non-compliant citizens

**Voluntary compliance**

Voluntary compliance differs from the former two methods as it involves a willingness to voluntarily comply with the regulatory requirements, rather than being compelled to comply (Australian Government, 2013). Voluntary compliance is often self-motivated. People willingly choose to follow stipulated rules to fulfil moral obligations (Murphy, 2017). Voluntary compliance is often a measure of:

1. An understanding of the need for the regulatory requirement
2. Confidence that the theory validating the regulation is sound
3. Assurance that compliance will lead to the desired results (Australian Government, 2013).

**k. Code compliance in developed countries**

Developed countries have continued to improve building codes and regulations in response to hazards, structural failures and health disasters (GFDRR, 2016). Japan and Australia provide two case study examples. Both countries share a heavily regulated building sector where code compliance is mandated.

**Building code compliance in Japan**

Japan is known for its vulnerability to various hazards and likewise for its strict building codes—and how they may be applied to assist in improving public safety within the built environment. Japan provides an important case study as it was initially similar to many developing countries in terms of its poor construction quality and limited technical knowledge (WBDRMH, 2017). However, through gradual change to the legal and policy system, the country has created one of the most rigorous frameworks that achieves a high level of building safety. In this manner, Japan serves as a model for those countries wishing to strengthen local policy to assist building resilient communities.

Within the current system in Japan there are three predominant laws in force: Building Standard Law (BSL), the Fire Service Law and the City Planning Law. While the former two are primarily concerned with life safety (and associated property protection), the latter relates more to the creation of liveable cities (Okasaki, 2007). Importantly, the building codes within the BSL are enforced throughout the country on a national level, with consideration for structures, fire and equipment (Okasaki, 2007). In addition, they are performance based building codes (Okasaki, 2007) to allow for flexibility in design and construction.

The building approval and regulatory procedure in Japan presents a staged system: design (preparation of drawings), construction commencement, construction, completion and building occupation. Within the design, construction and completion stages there are requirements for approvals to be obtained (certification) from the regulatory authorities (Figure 8) (Kamemura, 2016; Okasaki, 2007). Although a formal and comprehensive system of regulation exists, it is worth noting
that the system is subject to change: most recently this has involved inclusion of ‘Start of occupancy’ and ‘Owner’s periodic reporting’ levels (Kamemura, 2016).

The World Bank Disaster Management Hub (WBDMH) (2017) identified ten lessons from Japan’s regulatory system that may be considerations for those in developing nations:

1. “Regulation should be understood as a tool to guide and support the safety of the built environment and should not be seen principally as a means of exerting control.

2. To develop an effective approach to building safety, countries need a clear understanding of their available human, technical, and financial capacity.

3. Effective regulation takes place within an enabling environment that includes education, financial incentives, and other mechanisms designed to proactively support compliance.

4. The regulatory ecosystem must make professional expertise and technical services available to all who wish them.

5. Formal regulatory systems should recognize prevalent construction practices, including non-engineered construction, and the risks associated with them.

6. An effective regulatory regime is based on science and requires the participation of academia.

7. Governments can strengthen their regulatory regimes by coordinating action with the building industry.

8. The private sector can play an important role in effective enforcement of building regulation, but only where mechanisms for oversight, fairness, and conflict resolution are robust.

9. Financial incentives can play a key role in promoting safety and overall quality in the built environment.

10. An incremental, context-specific approach – one in which policies are based on analysis of data accumulated over many years and events – is the path to a safer built environment” (WBDMH, 2017, pp. 2-4).
Building code compliance in Australia

Australia presents a slightly different perspective. Within Australia the different States and Territories maintain individual planning legislation that relates to the National Construction Code (NCC): the technical building provisions. Although the legislative process of obtaining building permits, inspection regimes and so forth may differ in States and Territories according to their planning legislation, the NCC is the standardised document providing uniform requirements with minor variations depending upon geographical conditions. When compared to most developing countries, Australia has a high building code compliance rate and according to the Australian Building Codes Board the high rate of compliance is due to a shift towards performance based over traditional prescriptive based building code requirements that were introduced in 1996; whereby, such provisions provided flexibility in the selection of products and methods of construction (ABCB, 2018).

Essentially the NCC is a performance based code where it has overarching performance requirements that must be complied with. However, compliance may be attained by complying with the provisions ‘clauses’ set out within the document, by development of a performance solution or a combination of both methods. While compliance with the Performance Requirements within the Code remains mandatory, there is the ability to consider innovative construction, heritage buildings, as well as advances in technology and materials (ABCB, 2016). The present NCC is divided into multiple volumes to address the needs of different development types covering a range of themes (Figure 9):

- Volume One: Building Code of Australia (BCA) Class 2 to Class 9 Buildings (aligned with high-rise residential, commercial and industrial)
- Guide to Volume One
- Volume Two: Building Code of Australia: Class 1 and Class 10 Buildings
- Volume Three: Plumbing Code of Australia (ABCB, 2016)
The policy system surrounding implementation of the NCC is complex and as noted, differs across the States and Territories; however in each case, drawings are assessed by a regulatory authority, permits are required before construction work can commence, regulatory inspections must be undertaken during construction and upon completion of works a final inspection and certification must be obtained prior to building occupation.

![Diagram of NCC BCA Volume One and Two](image)

Figure 9. Examples of NCC content relative to development type
(Adapted from Australian Building Codes Board, 2016).

1. **Code compliance in developing countries**

As formerly noted, building and planning regulations are seen as a powerful tool to increase community resilience in relation to disaster events (Bernicat, 2015; World Bank, 2015). According to GFDRR (2016), the low level of sophistication of regulatory frameworks in developing countries places them in a less favourable position when it comes to enforcing building codes and regulations. The key issue being that many of the building codes in developing countries have been adapted from developed countries (Johnson, 2011; World Bank, 2015), but being poorly implemented, often dysfunction and with a frequently top-down approach, the codes prove difficult to implement in the socio-economic conditions of the developing world (GFDRR, 2014).

Developing countries are known for a high level of informality in the building sector and the case is not always due to the absence of regulations, but low level of compliance that is often due to factors such as inadequate monitoring, transparency and an ineffective legal system. Furthermore, corruption,
favouritism and poor enforcement impede compliance in the developing world (GFDRR, 2014). Beyond the structural issues in developing countries, researchers and organisations have attempted to ensure safety in informal settlements by regularisation and creation of standard and resilient structures with traditional knowledge (Fernandes, 2011). The following examples briefly consider Kenya and Turkey (as highlighted in the GFDRR 2014 report) in relation to the issues that have resulted in poor construction practice and unfortunately resulted in devastating impacts following a disaster event. The case of Peru provides a different perspective: an illustration of strategies employed to help increase resilience within the built environment.

**Building code compliance in Kenya**

Within Kenya, the building code regulatory system was derived from colonial standards and as such maintained a hierarchical top-down approach. Primarily, it was a combination of urban planning and in terms of the codes ‘affordability’ that resulted in policy implementation failure. With many of the population unable to access standardised construction materials due to cost, the policy system of the development sector essentially collapsed (GFDRR, 2014).

**Building code compliance in Turkey**

Turkey had formulated a rather comprehensive building code that included earthquake provisions; however, the implementation system failed as violation of code requirements became commonplace: disregarding technical requirements and building additional ‘unapproved’ levels, for example. Corruption was also identified as a contributor to the system which exasperated poor practice. These activities had a devastating impact upon local communities during the 1999 earthquake where more than 17,000 people died, and 65 percent of residential units were deemed non-compliant (GFDRR, 2014).

**Building code compliance in Peru**

Peru, like many Latin American countries is characterised by widespread informal settlements. The country worked in collaboration with the Intermediate Technology Development Group (ITDG) (now Practical Action), an international and non-governmental organisation, to focus on providing affordable housing for the poor through the provision of building materials, construction technology, employment and sources of livelihood (Majale, 2004). Following the 1990 earthquakes, ITDG introduced a participatory reconstruction project to assist residents with building earthquake-resistant buildings. The organisation worked closely with community members and local contractors by educating them on innovative technologies for earthquake resilience (Majale, 2004).

Attempts to ensure safety within such communities included the land titling programs which started in 1996 (Fernandes, 2011) and supports from ITDG. Although lack of title has been a major issue associated with informal settlements and the associated vulnerability, a review of titling across the country revealed that the process has not solved the deeper causes of vulnerability within the settlements. There has not been a significant investment in infrastructure in those areas, neither are residents granted access to credit (Fernandes, 2011). Ultimately, the titling program has created opportunities for informal landowners to obtain legal titles for their residences.

The systemic issues in developing countries is multi-faceted, however, strategies and attempts to empower the most vulnerable have been associated with a level of success as evident in Peru. However, despite the shortcomings of the program, the assurance and security of land ownership may potentially facilitate better construction practices.
8. Encouraging code compliance

The World Bank Disaster Management Hub (WBDRM) (2017) argues that:

“Building regulation has a crucial role to play in reducing disaster risk. Building codes can lessen vulnerability by specifying adequate standards for exposure by guiding development away from the most hazard-prone areas” (p. 1); and that “[b]y incrementally raising building standards and working to create effective regulatory compliance mechanisms, developing countries can save lives, protect housing and other assets, and contribute to an overall safer built environment” (p. 1).

An effective building code regime requires a legal and administrative framework at the national level, with building code development and maintenance processes and implementation at the local level (World Bank, 2015). By learning from the experiences of developed countries, developing countries can reach a high level of maturity in reinforcing and complying to building codes (GFDRR, 2016). However, adaptation is required to ensure compatible for the local context to ensure implementation success (World Bank, 2015).

Yet in developing countries where non-compliance is common practice and enforcement low, the question is raised as to how code compliance can be encouraged. The following factors suggested by UNESCAP (2012) outline a range of issues for consideration when investigating mechanisms to encourage compliance:

1. “Keep it simple
2. Raise awareness
3. Provide incentives
   a. Offer special housing loans
   b. Relax zoning restrictions
   c. Offer tax breaks
4. Attack the issue from all sides
5. Transfer responsibility to the private sector” (pp. 14-15).

In many respects these elements are straightforward and may assist in creating a compliant society; however, UNESCAP (2012) saw the need to go beyond high order statement and review in terms of a local level application. Subsequently, UNESCAP (2012) proposed that the following five factors must be considered within the local context when considering how to encourage compliance:

1. Financing: financial incentives are acknowledged as a mechanism by which to encourage compliance. Through such incentives, it is possible to make immediate sectoral change; however, this factor requires large capital, resources and a conforming political context.
2. Human resources: building capacity across the sector between all stakeholders assists with awareness, understanding, and ultimately, compliance. There is a need for all stakeholders involved in the building cycle to have knowledge of the codes and consequences for non-compliance. This extends to those responsible for regulation (e.g. council), implementation (e.g. engineers, builders) as well as owners and buyers.
3. Enforcement capacity: traditionally the regulatory authority has been responsible for enforcement activities and compliance is attained in countries where governance is generally
strong. However, where government enforcement capacity is limited alternative regulators may assist with encouraging compliance (e.g. banks, insurance agencies).

4. Stakeholder cooperation: for successful policy implementation and compliance, cooperation amongst stakeholders is essential. UNESCAP (2012) states that ‘enforcement is most effective and efficient if government takes the lead...’ (p. 16). However, cooperation extends beyond the government entity as the community and construction industry needs to be involved and supportive: to raise awareness around the importance of regulation for human safety.

5. Other contextual factors: the individual characteristics of a place, combined with political and economic situations need to be considered when determining measures to encourage compliance. By understanding the context, the most suitable mechanisms can be employed to encourage compliance (UNESCAP, 2012).

m. Facilitation mechanisms

Key drivers for encouraging building code compliance in developing countries were highlighted by World Bank (2015) to include:

*Improving legitimacy and procedural justice:* The bulk of work here lies on the shoulders of enforcement officials. Procedural justice involves fairness, trust and open communication that assist building relationships and encourage compliance.

*Designing regulatory processes to support compliance:* by striking a balance between enforcement and compliance support may foster transparency, respect and limit resistance. In addition, building capacity and encouraging compliance can be considered in terms of seven points of intervention to:

1. “Establish a sound legislative and administrative foundation at the national level.
2. Develop a building code suitable to local social and economic conditions that facilitates safe use of local building materials and practices.
3. Strengthen implementation of building codes through plan review, site inspection and permitting at the local level.
4. Support code compliance, provide advisory services in addition to inspection and enforcement.
5. Take advantage of opportunities for regulatory interventions.
6. Clearly identify hazard zones and restrict development according to exposure.
7. Advance supporting institutions” (World Bank, 2015, p. 80).

n. Reviewing compliance challenges

Building codes and regulations are primarily for the safety of people, despite this however, compliance to these codes and regulations is yet to reach its optimum levels. GFDRR (2015) suggests that non-compliance is a bigger problem in developing countries and this is often caused by a range of factors including low income level, unaffordability of formal housing stock and deeper social and institutional issues within those countries. According to the World Bank (2015), some of the key issues are:
1. Ineffective land use system: allowing settlements within high risk zones.

2. Weaknesses in building code administration and institutional capacity: incorporating insufficient resourcing to enable effective regulation.

3. Insufficient legislative foundation: national legislative deficiencies and issues associated with implementation.

4. Unaffordable compliance costs for the poor: lack of consultation with local level agents creating unrealistic standards.

5. Insufficient recognition of prevalent building practices: regulations often do not consider that building is staged to accommodate funding and material availability.

6. Dysfunctional regimes of building controls: inspection activities are often complex and an economical burden increasing overall costs.

7. Corruption and regulatory capture: results in reduced safety standards.

9. Conclusion

Safety in the built environment is a priority for governments and the essential purpose of building codes and regulations. However, codes are of no use if there is a low level of compliance, hence the examination of the various subjects that relate to building codes and compliance with a brief comparison of practices in developed countries and developing countries was undertaken in this project. The brief literature review has highlighted systemic irregularities, lack of legitimacy and procedural justice as key issues impeding compliance in developing countries and not necessarily the absence of codes. Furthermore, attention is drawn to the need for more contextualised codes that addresses the issues associated with the traditional means of construction and informal settlements.

The following sections provide backgrounds and case studies of building codes (or lack of) and the results for buildings and population in Bangladesh and Nepal. The case studies assessed the views of various stakeholders on the issues and challenges surrounding safe building codes for ensuring disaster resilience.
Figure 10. Informal housing, Bangladesh
SECTION 2: Case Study: Bangladesh

Bangladesh, a densely populated South Asian country, is highly vulnerable to different types of hazards (flooding, riverbank erosion, cyclones, drought, landslides, earthquakes, building collapse, etc.). Dhaka, the capital city, is centrally located and is an economic, social and cultural hub. Large migration takes place from rural areas of Bangladesh to Dhaka for employment and other opportunities: currently the city accommodates nearly 20 million people. In order to host this huge population, over two hundred thousand buildings have been constructed—often in a haphazard manner—rendering them highly vulnerable to different hazards (Figure 10).

The Bangladesh National Building Code (BNBC) and the building and planning regulations of the Dhaka Development Authority (RAJUK) are the key instruments for ensuring building safety. The Bangladesh case study consists of attempts to assess various stakeholders’ opinions in Bangladesh on the issues and challenges of compliance to safe building codes for ensuring disaster resilience. Twenty-two individual stakeholders (academics, professionals, engineers, masons, etc.) were interviewed to assess their experiences with building codes in the city. In addition, four Focus Group Discussions (FGDs) were undertaken, involving a range of stakeholders including private companies and construction professionals such as masons. The stakeholder/expert interviews revealed that:

- Those who are involved in the city’s construction activities are in most cases not aware of the BNBC.
- Landowners were found to be reluctant in implementing the BNBC, as they are not willing to expend the additional costs for building construction.
- Workers involved in building construction were not found to be interested in compliance to codes as there remains no incentive to comply.
- There remains no government authority that actively promotes and monitors the implementation of the BNBC.

The incorporation of the BNBC into university and trades-school curricula can be promoted to provide proper training to built environment professionals and relevant others. In addition, continuous dissemination of the BNBC through different media (TV, radio, newspapers, etc.) is required.
10. Geography and population of Bangladesh

Bangladesh—a South Asian country with a population of 160 million—records the highest density (around 1200 persons per km²) in the world and is highly vulnerable to different types of natural and man-made hazards. Physiographically, the country’s significant part (nearly 80%) consists of low lying floodplains (Brammer, 2012). Geologically, the country is located in the active margin of the Indian and Eurasian tectonic plates. Thus the entire north-south elongated eastern part of the country is vulnerable to earthquakes. In addition to the existing natural risks, a significant number of man-made hazards (building collapse, fire incidences, etc.) are also of great threat. As rural areas lack sufficient employment and other opportunities, people migrate to cities, particularly to Dhaka, the capital. Although the urbanization level currently is still low (around 30%), by 2050 it is expected that almost 50% of the population will be living in urban areas (Islam, 2005).

Dhaka (Figure 11) is centrally located and is considered the hub of economic and socio-cultural activities. The city currently accommodates nearly 20 million people (UNDESA, 2017), while it records nearly 70% of the total urban population of Bangladesh. The city’s density is over 40,000 persons/km² (Islam, 2005; Kabir et al., 2018) and has experienced phenomenal growth in the last few decades, while in some wards of Dhaka South City Corporation (DSCC) the density exceeds over
200,000 per km² (Islam, 2005). In order to accommodate this large number of inhabitants, the city has been developed in a very unplanned and haphazard manner. More than two hundred thousand buildings have been constructed in the city mostly without maintaining the building regulations, posing a risk for most of the city dwellers. Poor urban planning, excessive population density and presence of an informal settlement population of over four million has exacerbated the conditions (Angeles et al., 2009).

11. Impacts of disasters on buildings and people in Bangladesh

Dhaka has already experienced several large-scale building collapses and fire incidents where thousands of people have been severely affected. Therefore, it is pragmatic to ensure the application of compliance to safe building codes. In addition, due to rapid unplanned and unregulated urban expansion, Dhaka suffers from problems associated with lack of rainwater drainage, leading to flooding during the monsoon season. The city experienced destructive flooding events in 1987, 1988, 1998 and 2004 mainly due to excessive rainfall (Dewan et al., 2007), severely affecting a large number of city dwellers and their dwelling units. Localised water build-up in the rainy season in different parts of Dhaka is a regular phenomenon due to inadequate drainage, filling up of water bodies and extensively built-up areas. Therefore, it is important to ensure compliance to safe building codes to enable resilience and reduce such devastating impacts.

According to a recent survey of a national daily newspaper, about 78,000 buildings out of 326,000 in Dhaka have been identified as vulnerable to disasters (Sarker, 2009). It is often reported that an earthquake with moderate intensity can produce a significant havoc of building collapse. Due to non-compliance to building codes, the city has faced a number of devastating disasters within the last couple of decades. These have included building collapses, fire conflagrations and earthquake impact. In all cases, non-compliance to the building codes have compounded the impacts, resulting in significant property damage and unfortunately large death tolls. Among all the disasters experienced by Dhaka, the collapse of the Rana Plaza garment factory (2013) has been the most devastating, killing over one thousand people, with non-compliance to building codes contributing significantly to its collapse.

0. Major fire incidences in Dhaka

In Dhaka, fire is becoming an unmanageable threat particularly in high-rise buildings mostly constructed in a manner that violates the national building code. Various incidences of major fires in different types of buildings are described below.

Fire incidence in Nimtoli, Old Dhaka

A severe fire broke out in the densely-populated part of Old Dhaka city at Nimtoli on 3rd June 2010 (Figure 12). The flames gutted eight buildings and over 20 shops, and killed 120 people at Nawab Katra of Nimtoli, and resulting in injury to approximately a further two hundred people: most of the affected people were women and children. Initially it was thought that explosion of two transformers at Nimtoli started the fire, but it was later found that the fire originated from an oil stove and spread to nearby chemical warehouses and resulted in the high casualty figures and damages (Imam, 2010).
It has been identified from this incident that an absence of urban planning or deviation from codes was a contributing factor to the devastation. Moreover, the density of the residential area affected made it difficult for firefighters to quell the blaze. The narrow lanes of old Dhaka and staircases of old buildings made it difficult for fire services to enter the area. Thus, casualties increased due to non-compliance with RAJUK setback regulations (Imam, 2010).

Fire at Japan Garden City

On 12th February 2010, an acute incidence of conflagration in Japan Garden City (Figure 13) occurred as a consequence of residential and office building construction that had inadequate fire management provisions: violating the BNBC. In one of the buildings of Japan Garden City, seven members of a family lost their lives when fire lit up in the tenth storey of the building. There were only a few fire extinguishers and water hydrants serving the building and unfortunately it was identified that no occupants were able to operate the equipment nor were they in working order. Even after a charge was levelled at RAJUK, no response was received on how this building was approved to be built with such inadequate fire management systems (The Daily Star, 2010a).
p. Major building collapses in the last decades in Dhaka City

Begunbari building collapse

On 1\textsuperscript{st} June 2010, a five-storey residential building suddenly collapsed at Begunbari, Dhaka. The building was adjacent to shanty dwellings, and unfortunately the collapse impacted this area and the collapse also impacted them. Tragically, 25 people died as a result of the collapse with more and more than 50 people were injured (refer Figure 14) (The Daily Star, 2010b).
From the way in which the building collapsed, it was evident there was no proper plan for the building, nor any rule or code was followed in its construction. Furthermore, it was identified that workmanship and engineering as well as the materials that went into the making of that building were also of very poor quality contributing to the devastation. An improper site had been selected for its construction as the land had been filled using garbage instead of soil. Additionally, some heavy construction materials had been stored on the top floor of the building, which contributed to the collapse. Another major factor was that the foundation was not designed properly and the connection between the columns and the base was not adequate (The Daily Star, 2010b).

**Spectrum sweater factory collapse**

On 11th April 2005, the seven-storey Spectrum garment factory collapse took place at Palashbari in Ashulia, a suburb near Dhaka (Figure 15). The building was designed for 4 storeys, but 9 storeys had been built (Institute of Engineers Bangladesh, 2007). The building was constructed on soft soil on swampy land, using poor quality building materials, resulting in the whole design being faulty and non-compliant. An explosion of a boiler on the ground floor was also a contributing factor to the collapse. About 73 workers were killed and more than 85 were seriously injured (Institute of Engineers Bangladesh, 2007).

![Image of Spectrum sweater factory collapse](image)

*Figure 15. Spectrum sweater factory building collapse 2005. Image: Zahedul I Khan, courtesy of The Daily Star*

**Phoenix garments factory collapse**

On 25th February 2006, a six-storey commercial building collapsed in central Dhaka at Tejgaon (Figure 16). This building collapsed mainly due to structural failure. The building was originally constructed as a commercial building; however, in 2005 it was converted to a 500-bed hospital. The
main reasons behind the collapse include unplanned construction, poor building materials, and non-compliance to RAJUK regulations and BNBC (The Daily Star, 2006).

Rana Plaza building collapse

On 24th April 2013, ‘Rana Plaza’, an eight-storey garment factory building, collapsed in Savar, a suburb of Dhaka. The collapse of this building is considered to be one of the deadliest garment factory accidents in history, as well as the deadliest structural failure (Figure 17) (The Daily Star, 2018).

The building has become a symbol of poor compliance concerning workplace safety and security in Bangladesh’s industrial sector, and an icon of poor attention to the working conditions in garment factories in developing countries. According to the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) nearly 4,000 workers were in the building at the time of the collapse. After over a month of search-and-rescue operations, a death toll of 1,134 and 2,500 serious injuries were listed (IGHLHR, 2014; Australian Broadcasting Corporation, 2016b; The Daily Star, 2018).

The main reason for collapse of this building was attributed to structural failure, again, a result of non-compliance to RAJUK laws, building codes or other regulatory requirements of Bangladesh.
The building was originally designed for 5 storeys; however, a total of 8 storeys were constructed. The building was also converted from a commercial use to industrial with no additional provisions for safety. It was constructed on a pond filled with loose material which compromised its structural integrity. The use of substandard building materials, aggravated by vibrations due to the generators inside, was a further reason for such devastating damage.

12. Building regulations in Bangladesh

q. Bangladesh National Building Code (BNBC)

In Bangladesh, the BNBC was first drafted in 1993, but not until recently the process of formally reviewing or updating the codes has taken place. In 2006 the Building Construction Act was amended to include a new section 18A, and on 15 November 2006 it came as a gazette empowering the government to promulgate the building code as a legally binding document. In December 2009 the House Building Research Institute (HBRI) involved leading experts from Bangladesh Road Transport Corporation (BRTC), Bangladesh University of Engineering and Technology (BUET), Bangladesh Standards Testing Institute (BSTI) and outside to update the code and act within a year and then made it available to all. In 2016 its latest edition was published as a draft copy which has not been gazetted yet. According to HBRI, it is expected to have this edition gazetted by 2018.

The purpose of the Bangladesh National Building Code is to establish minimum standards for design, construction, quality of materials, use and occupancy, location and maintenance of buildings within Bangladesh in order to safeguard, within achievable limits, life, health, property and public welfare (HBRI & BSTI, 2006).
The provisions of the code apply to the design, construction or occupancy, alteration, moving, demolition, repair of any building or structure and to any appurtenances within or connected (HBRI & BSTI, 2006). It is stated that the provisions of the code are applicable to all persons of Bangladesh.

Since 2006, the code has been made mandatory for compliance with any building construction under the Building Construction Act of 1952, to ensure accountability in the management of overall building construction and safety of the buildings. According to section 2.1 of chapter 2 of part 1 of the BNBC 1993, the government is under obligation to establish a new, or designate an existing, agency for the enforcement of this code within a given area of jurisdiction. However, the government is yet to establish such an agency. Thus, there is an absence of a regulatory authority responsible for all safety aspects of buildings as per BNBC and this remains a major concern. Section 2.6 of Part 2 of the BNBC only states that violation of the code will be an offence and the authorities can take legal action. However, it prescribes no procedure for institution of legal proceedings, which needs to be addressed. The provisions of the Building Construction Act 1952, along with the code need to be updated, taking into consideration the present socio-economic situation of the country.

r. Addition in the new draft edition of BNBC 2010

The 1993 BNBC has dealt with a range of development areas including construction, structure, material, geo-technical and seismic aspects. As evident from section (f), the 1993 BNBC did not include environmental influences on planning, design, construction and selection of construction materials.

In the latest edition of the BNBC (HBRI, 2016), new forms of permit and inspection were introduced. When modifying the building code, the City Development Authority (RAJUK) regulations were also included. Classification of occupation, and definitions and general agreements have been changed and updated through consulting different international codes whereby a range of designs have been considered. Subsequently, types of building construction have been broadly classified into two groups: non-combustible and combustible types. Non-combustible types are further subdivided based on fire ratings. Combustible type is mainly timber or wood-based construction, which is subdivided based on the type of timber (HBRI & BSTI, 2006).

Additional considerations have been introduced or revised to align with combustion types and assist in the construction of safer buildings. The considerations include updated specifications for building materials in the latest edition, with two new chapters on bamboo construction and steel composite structures. Strength specification design for concrete structures has been rationalised and loads on buildings and structures have been updated. Confined masonry has been introduced to the masonry structures chapter to further strengthen structural adequacy of new builds against disaster events. Existing provisions for electric services, building acoustics, sanitary systems, water drainage, and lifts and escalators were thoroughly revised along with provisions on sustainability measures. Guidelines for signage in urban and rural areas have been introduced and standardised environmental graphics and graphics for universal accessibility have been added.

In this new draft, precautionary requirements were modified according to revised building occupancy classification. In terms of disaster situations, specific requirements for fire protection have been introduced and the earthquake load has been revised based on the Euro Code and the Indian Code. Furthermore, provisions for environmental protection and high-rise buildings are now included with minor changes made to storage, handling practices, and supply of fuel and gas.
Significant revisions have addressed current climate change concerns. In the original 1993 Code, the calculation of basic wind speed was based on the fastest speed. In the new 2016 draft edition, this figure has been amended to ‘3-second gust speed’ which is about 11 percent higher than the basic wind speed. In Dhaka, formerly a figure of 210 km per hour was employed, and this has been updated to reflect that it is now about 236 km per hour. Similarly, there are plans to increase wind pressure by 4 to 5 percent. The seismic design category is included in the code as it is most vital for structural design and relates to the soil conditions. In the new draft edition, the whole country is divided into four different zones with every building in zones 3 and 4 to be designed as ‘Special Moment Frames’ to handle movement during earthquakes. From the amendments and proposed changes to the new draft, it is evident that significant emphasis is being placed upon building codes to minimise severe impacts from disaster events and ultimately protect life. The next phase of this process may involve consideration of a regulatory authority to assist with compliance, and importantly, education to raise awareness of the safer building codes.

s. Land development rules for private housing 2004

The Land Development Rules for Private Housing is a legal instrument for controlling land development in the private sector housing. The rules provide procedures and guidelines for land development protecting the environment. They detail the percentage of land that must be kept for community facilities, amount of land to be sold out, school sites, road hierarchy, and importantly, planning standards including, for example, the allocation of land per 1000 persons. In RAJUK there are very few planners working in large cities such as Dhaka. There has been consideration given to the establishment of decentralised zonal RAJUK offices that divide the city into different zones. According to the government’s Comprehensive Disaster Management Programme (CDMP), almost 65% of the structures in the city are built on soft land acquired by filling up water bodies. The majority of these buildings were constructed by both a violation of planning regulations and building codes.

13. Building construction practices in Dhaka

Dhaka is one of the fastest growing cities in the world (Berkowitz, 2013). Rapid urbanisation is currently occurring and the city of nearly 20 million people is growing year by year. Large population growth demands various types of buildings and construction works. Slums, semi-permanent, permanent, single and multi-storey building construction is a widespread scenario in the city for diverse purposes such as residential, commercial, industrial, educational and health. While the widespread informal settlements consist mainly of slums and semi-permanent types for residential use (Islam, 2005; Angeles et al., 2009).

Dhaka City Corporation was established as ‘Dacca municipality’ in 1864. Later it was renamed twice, first in 1983 as ‘Dhaka Municipal Corporation’ and finally in 1990 it was renamed as ‘Dhaka City Corporation’. In December 2011, Dhaka City Corporation divided into two independent city corporations called ‘Dhaka South City Corporation’ and ‘Dhaka North City Corporation’. In fact, in the infrastructural development of Dhaka South City Corporation (older part of the city), most of the
zones were formed more than 100 years ago, where about 95% buildings of this zone were built without adequate construction equipment, proper construction process, within a context of lack of proper urban planning and proper landuse planning. Within these zones most of the buildings were built haphazardly. In some areas of this corporation, some of the buildings constructed over the last few decades appear to follow RAJUK laws, but not those established by the BNBC.

The scenario of Dhaka North City Corporation is relatively better from the perspective of building construction and urbanisation. The North City area was built covering 56 wards and there are about 5 million inhabitants at the northern part of the megacity (Kabir et al., 2018). In the recently developed areas within the city corporations, building owners are now increasingly aware of the existing building rules and regulations of the city development authority, as building constructions are gradually being controlled by RAJUK. In older areas it has been observed that the landowners, engineers and planners still remain unaware of the existing building codes and their importance. Ultimately, the landowners are reluctant to spend extra money to achieve compliance with the code requirements.

14. Research approach and methodology

The methodology of this study is linked with the main research question - “How can compliance to voluntary safe building codes be facilitated in the current context of Bangladesh for increased disaster resilience?”

The study was undertaken based on primary and secondary data from different parts of Dhaka. It was decided to focus on Dhaka because of its national prominence.

t. Data collection and analysis

For the present study, primary data collection was carried out through interviews across different relevant institutions and concerned personnel, particularly those with experience on building codes.

Data collection was carried out in 2 stages.

Stage 1 involved semi-structured interviews with key stakeholders who have prior experience with building codes. A total of 22 individual experts/ key stakeholders from various government agencies, autonomous bodies and private companies were interviewed (Table 1, Figure 18 and Table 2). Interviews were recorded and later translated into English.

Stage 2 involved four focus groups discussions (FGDs) (Table 3, Figure 19 and Table 4). FGDs involved contractors, sub-contractors and masons. Discussions were recorded and translated into English.

Data was subjected to thematic analysis - a three-stage coding process to identify themes. Responses have been analysed through coding methods and descriptive statistics.
### Details of interview participants

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of Stakeholders</th>
<th>No. of Interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Academic institutions</td>
<td>3</td>
</tr>
<tr>
<td>02</td>
<td>Govt. organisations (Management level)</td>
<td>3</td>
</tr>
<tr>
<td>03</td>
<td>Govt. organisations (Operations level)</td>
<td>2</td>
</tr>
<tr>
<td>04</td>
<td>Private Companies (Management level)</td>
<td>3</td>
</tr>
<tr>
<td>05</td>
<td>Private Company (Operations level)</td>
<td>3</td>
</tr>
<tr>
<td>06</td>
<td>Civil Work Subcontractor</td>
<td>2</td>
</tr>
<tr>
<td>07</td>
<td>Foreperson</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

#### Table 1. Individual Interview Structure

#### Figure 18. Distribution of Interviewees by type
<table>
<thead>
<tr>
<th>No.</th>
<th>Stakeholders</th>
<th>Specialisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Academics</td>
<td>Earthquake, building construction, disaster prevention and urban safety, seismology, construction vulnerabilities to earthquake hazard</td>
</tr>
<tr>
<td>4</td>
<td>Government Authority</td>
<td>Detail Area Plan (DAP) (RAJUK)</td>
</tr>
<tr>
<td>5</td>
<td>Government Authority</td>
<td>Disaster and Earthquake Resilience Project (RAJUK)</td>
</tr>
<tr>
<td>6</td>
<td>Government Authority</td>
<td>Fire Service and Civil Defense (FSCD)</td>
</tr>
<tr>
<td>7</td>
<td>Government Authority</td>
<td>Fire Service and Civil Defense (FSCD)</td>
</tr>
<tr>
<td>8</td>
<td>Governmental Authority</td>
<td>House Building Research Institute (HBRI)</td>
</tr>
<tr>
<td>9</td>
<td>Construction Company</td>
<td>Mukta Construction Ltd</td>
</tr>
<tr>
<td>10</td>
<td>Real Estate Company</td>
<td>Anwar Landmark Company</td>
</tr>
<tr>
<td>11</td>
<td>Real Estate Company</td>
<td>ASSET Developments Ltd</td>
</tr>
<tr>
<td>12</td>
<td>Developers Company</td>
<td>Durba Developments Ltd</td>
</tr>
<tr>
<td>13</td>
<td>Consulting Company</td>
<td>d.Zignscape Consultant Ltd (Structural, Architectural, Soil test Company)</td>
</tr>
<tr>
<td>14</td>
<td>Construction Company</td>
<td>Residential Developers Ltd Kochukhet, Dhaka Cantonment</td>
</tr>
<tr>
<td>15</td>
<td>Civil Work Contractor</td>
<td>M/S Subarna Enterprise</td>
</tr>
<tr>
<td>16</td>
<td>Civil Work Contractor</td>
<td>M/S Madina Construction</td>
</tr>
<tr>
<td>17</td>
<td>Civil Foreperson</td>
<td>Freelance</td>
</tr>
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</table>
v. Details of focus group participants

<table>
<thead>
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<th>S. No.</th>
<th>Type of Stakeholders</th>
<th>No. of FGDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Masonry Team</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Masonry Union</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4</td>
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</table>

Figure 19. Distribution of Masonry FGD Stakeholders

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of Stakeholders</th>
<th>Specialty</th>
<th>Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGD-1</td>
<td>Foreperson &amp; Mason</td>
<td>Civil work and Steel work Foreperson</td>
<td>Sipahibag, Khilgoan</td>
</tr>
<tr>
<td>FGD-2</td>
<td>Mason</td>
<td>Civil work and Steel work Mason</td>
<td>Bhuiyapara, Madartek</td>
</tr>
<tr>
<td>FGD-3</td>
<td>Mason &amp; Construction Worker</td>
<td>Civil work Mason and Construction Worker</td>
<td>Banasree, Rampura</td>
</tr>
<tr>
<td>FGD-4</td>
<td>Labour Union</td>
<td>Foreperson, Mason, Construction Worker, Helper</td>
<td>Meradiya Bazar, Banasree</td>
</tr>
</tbody>
</table>
15. Results – Interviews and Focus Groups

w. Participants’ perception on building compliance

For this project, twenty-two key stakeholders from academic institutions, government agencies and private companies were interviewed to identify the issues and challenges related to the implementation of building codes and compliance to safe construction in Dhaka with regard to disaster risk.

The interviewed academics highlighted that only around 10% of buildings in Dhaka comply with the building codes. Therefore, a significant part of the city’s buildings have been constructed without following the existing regulations. The government officials mentioned that there is no regulatory body in Bangladesh to monitor whether the building code requirements are being implemented. The review and approval of the building drawings is sometimes undertaken by RAJUK; however, this occurs only after the review by professional engineers and planners. Following the building approval, the construction process is not monitored.

In discussions with private developers, it was stated that building codes are maintained in the larger scale projects. In many cases, the developers also follow the codes’ requirements as they have the technical staff and qualified engineers to undertake this role. Private building owners and small construction companies in most cases violate the codes. They do not recruit qualified engineers to avoid higher costs. Private companies may send the materials for testing to relevant laboratories of different government agencies and engineering universities. However, it often takes too long to receive test results, and in some cases incorrect results are received. Given the time delays, private companies identified that they do not wait for the test results and often start construction: in violation of the building codes. Furthermore, private company personnel also reported that a building design may be completed by structural engineers and architects, but in the field the site engineers execute according to the specifications and drawings without giving attention to whether the building compliances are ensured or achieved. It was evident that until recently, there has been no regulatory board for monitoring and implementing the BNBC. In most cases, high-rise buildings, or commercial buildings and other official large buildings are currently constructed according to the building code requirements, but private landowners tend to neglect code requirements to avoid extra expenses.

Through the interviews it was identified that Dhaka’s building construction in the past mostly took place without the application of building codes and construction is often done by masons. In the interviews, the masons and contractors/sub-contractors stated that they had never heard about BNBC; rather they used to construct buildings based on the provided drawings and general compliance and site engineering instructions. They also reported that in most cases private landowners construct buildings in coordination with contractors/sub-contractors or the foreperson rather than employing skilled engineers due to higher associated costs.

The masons identified that they do not receive adequate safety measures from the landowners. RAJUK has to monitor the implementation of the building codes, but that is lacking and thus building owners often violate the rules including setbacks and other compliances. Very often, engineers and building owners instruct differently and this creates confusion amongst the masons and subsequently, directed by the building owner’s decisions, rules and regulations are not followed.
x. Reasons suggested by stakeholders for non-compliance with building codes

The interviews and FGDs indicated that the existing building codes are not implemented by the building owners during construction. Reasons behind non-compliance were identified by each participant cohort and are summarised below.

Experience of academics

- Absence of proper mindset.
- Lack of awareness among people on building codes.
- Buildings owners’ intent to reduce extra expenditure.
- Lack of awareness of codes by some engineers resulting in non-implementation.

Experience of government agencies

- Professionals in the construction sector are not aware of the BNBC.
- The BNBC is difficult to understand because it is written in English. The code employs complex terminologies and is only understood by engineering professionals.
- Lack of internal-organisational harmony, that is, industry fragmentation.
- Building owners are not aware of the consequences for non-compliance of the building codes.
- Many engineers are not acquainted with building codes.
- In general, the wider community, clients and construction workers have little or no idea about building codes and their importance.
- Lack of knowledge of engineers, architects and planners of the building codes and the necessity for compliance.

Experience of private companies

- Misconception on BNBC exists across the construction sector that its application incurs significant additional expense.
- Neglect of building codes by site-based engineers and officers due to a lack of concern about building codes.
- Lack of precise knowledge at all levels regarding building codes.
- Ignorance about building codes and insufficient skills of masons, forepersons and contractors in relation to the codes and administration.
- Many civil engineers do not have clear knowledge about BNBC.
- The issue extends beyond the BNBC: often masons and forepersons do not follow even the construction drawings provided.
• Construction workers do not want to extend effort to understand and apply the codes and their goal is often to reduce the construction period. In an environment where they do not receive safety equipment from the owners, they tend to neglect the codes/compliances.

Experience of the masons (FGD results)
• Masons receive no training on BNBC.
• Major challenges are the inadequate supply of building materials by the owners, differences of opinion between engineers and owners, unavailability of safety products.
• Around 95% of the masons do not have any knowledge on building codes.
• Masons do not receive any incentives or inspiration to adopt the codes, particularly as they work in an environment where they are not supplied with safety materials.
• Extra expenditure is one of the main reasons discouraging building owners to adopt building codes.

16. Measures to encourage compliance
y. Recommendations of stakeholders for voluntary compliance
Many participants identified measures they understood would encourage voluntary compliance to the codes and help construct safer buildings.

Perceptions of autonomous institutions
• BNBC and building compliance need to be included within the tertiary systems: in different courses in university curricula.
• Training programs are required on the importance of building codes for professionals who have already graduated.
• Proper implementation of the land use policy is required. Diverse types of buildings should be built as per allotted specific zone according to land use planning rules.
• Educational institutions need to develop and promote awareness programmes among the private sectors, real estate agencies and general community.

Recommendations of government agencies
• Avoiding complex and jargon language such as engineering terminologies. There is a need to produce plain language publications for easier understanding and use by the general population.
• Several volumes of BNBC are required to be published: including separate topics covered by each volume.
• An educational and awareness programme is necessary to inform people of the benefits of following BNBC and the negative consequences of non-compliance.
• Building owners can be provided with incentives like credit and certificates to encourage them to follow building codes.

• Land use planning also has a vital role to create and construct disaster-resilient buildings. To begin with, sub-soil investigations should be conducted to identify liquefaction potential due to earthquakes, so that risk sensitive land use planning can be undertaken.

• Public awareness should be raised by mass media and other campaigns such as seminars, workshops and mock drills.

• Training should be provided to all relevant professionals including engineers, architects and planners, along with sub-contractors, forepersons and masons.

• Monitoring cells need to be formed as soon as possible so that where necessary action can be taken.

• All new buildings need to be built as disaster-resilient incorporating the BNBC.

• Using land use planning and geo-engineering data new construction must be conducted according to specific zones.

• Provision of incentives can be a strategy. As Bangladesh is a developing country, building owners often find themselves in financial crisis while constructing buildings. Providing soft loans from the House Building Finance Corporation may encourage compliance. There are two elements in constructing a building: Structural drawings and Architectural drawings. An owner should get a loan only when they submit the structural drawings to RAJUK prepared by a professional engineer following the BNBC.

Recommendations of private companies

• All bodies relating to construction need to be concerned about building codes to build safe and disaster-resilient buildings.

• There is a need to train all the key stakeholders through workshops, seminars, TV-radio-newspaper advertisements.

• A bank loan policy should be flexible with nominal interest rates when following the BNBC.

• From the government level there should be a motivation/incentive for the relevant stakeholders.

• Implementing land use planning policy, using different types of construction needs to be considered in terms of specified separate zones.

• To promote the application of BNBC, the approval of a building design complying with the BNBC should be given expeditiously.

• To make people aware of the BNBC, workshops, seminars and training programs should be arranged.

• Different training programs can be arranged not only for the engineers, but also for managers, supervisors, foremen and masons on technical aspects of BNBC rules.

• Booklets, brochures or leaflets should be distributed with detailed and simplified building codes, benefits of following the codes, consequences of not following them.
• Construction workers should be given monetary incentives and training to make them interested in the BNBC.

• Construction to be carried out through proper land use planning.

Recommendations of masons

• RAJUK should formulate, monitor and implement land use planning policy precisely.

• Honest employees should be deployed for monitoring and field visits for the implementation of codes, because monitoring is a key factor in compliance.

• Awareness-raising activities need to be initiated. In this case, documentaries on BNBC can be broadcast on television and radio.

• Masons can be given incentives and certificates for good construction.

17. Recommendations of stakeholders for enforced and deterrent compliance

Suggestions of academics

• Many engineers do not have a professional license for designing or constructing buildings; therefore, their knowledge and skills are limited, yet they are designing and constructing. In this case, monetary penalty can be sanctioned.

• There is no assigned authority from the government side that will approve, monitor, and give occupancy certificate of a building as RAJUK does for Dhaka. The Bangladesh Government should establish such an authority to approve, monitor, provide occupancy certificate, as well as legal action in case of violating the rules.

• If any building is constructed violating building codes, then strong fines or imprisonment should be considered. Gas, electricity, and other services can also be disconnected as penalty.

Suggestions of professionals

• RAJUK is carrying out an urban resilience project. There are two sub components: one is improvement of building code enforcement and another one is implementation. Under this project, an international consulting firm is going to be appointed that will identify mechanisms to promote the implementation of the BNBC. To get building completion certificates/license, building owners need to fulfil some conditions. Otherwise they would not be able to get the license and No Objection Certificate (NOC) from respective authorities.

• A building should not get the electricity supply connection if proper building codes and safety rules are not maintained. Moreover, RAJUK should not provide a building permit unless proper building codes are followed.

• Before commencement of construction when the land owner applies for NOC, then the following factors should be considered as per BNBC:
  - Presence of 10-metre wide road in front of the building;
  - Availability of sufficient numbers of exits;
  - Availability of fire safety plans on each floor;
- Presence of active and passive heating, ventilation and air-conditioning systems;
- Installation of fire doors and fire detectors in the building;
- Availability of adequate water supply for fire extinguishers, training for fire evacuation, and fire drills.

**Suggestions from private companies**

- The building approval authority has to be transparent to avoid permits being issued through bribes and political persuasion.
- To implement the BNBC, the concerned city development authority must be accountable and transparent.
- The consultant team that designs the building can play a significant role. They should enforce the codes in the execution team (engineers, supervisors, electrician, foreman and masons) and can also inform the building authority about the importance of building codes.
- The structural department of the company should instruct the relevant personnel to follow building codes properly. They should introduce the codes and provide information about the penalties for violating the codes.
- Contractors/sub-contractors and masons should not receive their payment until implementation of code precisely as per design has been done. Persons not following the codes should also be fined.

**Suggestions of masons (FGDs)**

- Building codes are not followed in Bangladesh when constructing a building because owners encounter financial expenses when following the codes. In some cases, building owners do not want to follow even RAJUK setback rules.
- In 99% of construction sites in Bangladesh, safety is not being practiced. In this case, RAJUK should not issue NOC to permit the owners to commence the construction of the buildings until they assure that required safety measures are available on site. After receiving permission, building owners are not interested in the safety of the workers anymore. Injured workers and families of dead workers usually do not receive any compensation.

8 **Key findings and recommendations**

z. **Key findings**

- The building code is now included in the curriculum at the undergraduate level in prominent academic institutions like the Bangladesh University of Engineering and Technology (BUET).
- The general public continues to remain unaware of the BNBC and its importance to life safety.
- A significant number of planners, architects and engineers are not acquainted with the BNBC.
Building owners are often reluctant to invest additional expenditure for implementing the BNBC.

Poor monitoring and law enforcement is responsible for the lack of implementation of the building codes.

In most cases, the stakeholders assume that the code is only used for resisting earthquake events.

There remains a lack of proper training and awareness of construction workers.

The code is not followed currently.

The code is written in English and not easily interpreted by the general community which impacts upon compliance as it is only understood by certain professionals.

The building codes developed by BUET are not properly understood.

Malpractices in design and construction of buildings continue to be prevalent.

Lack of inter-organisational harmony exists amongst the industry.

Absence of a proper monitoring authority or regulatory board is preventing compliance to building codes.

Negligence of building codes by the site-based engineers.

Unavailability of an enforcement mechanism for implementation of the BNBC affects compliance.

Following building codes from the very beginning can help to avoid significant financial loss.

Many civil engineers do not have an accurate knowledge of the BNBC.

Land use planning is not maintained in Bangladesh and it is necessary to enforce rules and regulations to reduce risk.

Following building codes has the potential to make buildings durable against all hazards, not only earthquakes.

aa. Key recommendations

Convince owners to follow building codes so that after assessing the building they get a clearance certificate and they can make good profit.

Making owners aware of the high cost of retrofitting and the difficulties they will have to face to retrofit.

Showing and convincing through facts and analysis to the clients so that they can get a clear idea of the extra cost that will deliver them a lot of benefits over time.

Organizing workshops, seminars, drills, TV/radio/newspaper features, advertisements, etc for creating public awareness.

The inclusion of the BNBC in all engineering and relevant disciplines at universities should be mandatory.
• Contractors and masons should not be paid until they follow the exact design approved by RAJUK.

• Penalties should be imposed on those who do not follow BNBC.

• Creating awareness and providing training to stakeholders from the community level to respond to the impacts of disasters.

• Meetings should be arranged monthly headed by chief engineers, project operations head, structural head, advisors of the company and other such leaders where training and instructions are provided to employees.

• Council or committees of masons should provide their masons the information about rules and regulations of constructing a building.

• RAJUK should be monitoring and strictly controlling implementation of building codes.

• All bodies related to construction need to be concerned about building codes for a safe, disaster-resilient building.

• Bank loan policy should be flexible with nominal interest rate for construction that follows the BNBC.

• The government can initiate a policy such as, “If a building is designed complying to building codes, approval time should be less for the building permit.” (For regular building approval, it takes 2-3 months, but for BNBC-complaint it should be less than a month).

• Introducing people with the codes and penalties for denying codes.

• People should be warned of the disastrous consequences of neglecting the BNBC.

• Related institutions should work together for integrated planning.

• Providing occupancy certificates to encourage compliance.

• Providing soft home loans from House Building Finance Corporation if the BNBC is properly followed.

• Risk-sensitive land use planning has to be promoted for Dhaka and other cities in case of construction of buildings and other infrastructure.

• Owners should only be given home loans when they submit the structural design to RAJUK done by professional engineers following the BNBC.

• A manual should be produced in Bengali so that people can easily understand the main aspects of building codes.

• Workers should be given extra bonuses if they receive training.

• Owners both private and other must be brought under supervision.

• Safety management should be used in workplaces so that workers never neglect their duties; this should be monitored strictly.

• Buildings owners can be given incentives.

• Creating awareness so that people can understand that reducing the adverse effects of disasters is more important over the long term than saving money.
• Manuals should be published with detailed and simplified building codes.
• Providing credits and certificates which can be used later for getting other jobs.
• Fast clearance should be given to those who construct infrastructure following building codes.
• Arranging different training programs, workshops for engineers and seminars for building owners.
• Land and geologic characteristics should be taken under consideration for construction and proper urban planning.
• Land use planning and geo-engineering data can be used for zoning areas according to hazards and risks.
• Formulation of long-term land use planning is needed.
• The monitoring and implementing agency like RAJUK has to be transparent and accountable.

18. Future research opportunities

The successful implementation of building codes plays a vital role in making a city disaster-resilient. Cities like Dhaka and others in Bangladesh experience widespread violation of building codes. Hundreds and thousands of buildings that have already been constructed in Dhaka in a haphazard manner are at risk of collapse in earthquakes and other disasters. Therefore, the city should identify mechanisms through scientific investigations on how to effectively implement building code compliance. In this case, continuous assessment of opportunities and challenges should be carried out. Future research can include assessing different stakeholders’ opinions at a large scale encompassing all the communities of the city so that they can freely share their ideas and experiences. In addition, taking examples from countries where building codes are successfully implemented, research activities to explore mechanisms to promote such application of codes need to be initiated.

19. Conclusion

Bangladesh, a small country, hosts a large population while the capital city, Dhaka, accommodates close to 20 million people. Due to the large population, the city has been growing in a very irregular form and has urbanised in a very haphazard manner. Building construction at present and in the past has not been given due attention particularly with regard to the existing building regulations and codes. Therefore, over 90% of buildings that have already been constructed in the city are highly vulnerable to earthquakes and other hazards. The city has experienced several large building collapses where many people have died. Given these situations, it is extremely important for the city, and the whole country, to identify effective mechanisms to promote the implementation of building codes. Those who deal with the BNBC (e.g. engineers) should be taught at the university level through incorporating it into the curriculum. In addition, those who work in building construction can be trained through various ways. By giving them incentives and rewards, implementation of the BNBC can be promoted.
Figure 20. Housing construction, Nepal
SECTION 3: Case study: Nepal

Earthquakes represent the major and most devastating hazard in Nepal and the building codes of Nepal play a role on supporting the construction of earthquake resistant-buildings. However, existing codes do not include much information or provisions for making building floods or landslides resistant, even though Nepal faces such disaster events.

The case study focuses on earthquakes given they are covered in the National Building Codes of Nepal. Other hazards such as floods, landslides and drought also affect Nepal, but are beyond the scope of this report. Nonetheless, such hazards have been covered in the ‘Grey Building Handbook’, included here as an appendix and as a stand-alone publication translated into Bengali and Nepali.

20. Geography and population of Nepal

Nepal lies in the central part of the Himalayas (Figure 21). The country has been divided into seven provinces and presently has 293 urban municipalities. Until 2014, Nepal had only 58 municipalities; the increase in municipalities reflects the urban population growth. There are four types of municipalities in Nepal, metropolitan city, sub-metropolitan city, municipality and rural municipality. In March 2017, after a report by the Local Level Restructuring Commission, the country was divided into 4 metropolitan cities, 13 sub-metropolitan cities, 276 municipalities and 481 rural municipalities. Further, the number of metropolitan cities increased to 6 after the upgrading of two sub-metropolitan cities.

Figure 21. Map of Nepal, image courtesy of Mapcruizin.com
21. Impacts of disasters on buildings and people in Nepal

Nepal is one of the most vulnerable countries in the world in terms of natural hazards. It is in the top 20th position in the list of multi-hazard prone countries in the world (Gautam, 2017). Further, the country lies in an active seismic zone between the Indian and Eurasian plates (MoHA, 2015).

The country has regularly witnessed major earthquakes. The first recorded event dates back to 1255 AD where the ruling king Abhaya Malla was killed and one-third of the valley’s inhabitants perished in the same disaster (Rana, 1935). The destructive earthquake after 1255 was followed by other such events in 1408, 1681, 1803, 1810, 1833, 1934, 1980, and 1988) and continues today (Earthquake Loss Estimate, 2014). Furthermore, the country witnessed smaller earthquakes in 1988, 2001, and 2011.

One of the last great earthquakes was in 1934, measuring over 8.0 on the Richter scale and resulted in the death of 8,519 people with 207,740 structures damaged (Rana, 1935). The 1988 Eastern Nepal earthquake killed 721 people and injured 6,553, and 20,000 buildings collapsed or were damaged including 948 schools. The recent Gorkha earthquakes of 15th April 2015 and 12th May 2015, affected 31 districts of Nepal, of which 14 districts were declared ‘crisis-hit’. The 2015 Gorkha earthquakes claimed more than 8,790 lives with thousands affected. Furthermore, it has destroyed more than 500,000 houses and damaged another 250,000 (NPC, 2015). Many scientific research studies conducted following the Gorkha earthquakes speculate that another earthquake of this magnitude could be even more devastating (Grandin et al., 2015).

The impacts from earthquake events are often devastating and casualties and damage related to the Kathmandu Valley can be found in Table 5.

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Earthquake Epicenter</th>
<th>Casualties</th>
<th>Buildings / Temples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Death</td>
<td>Injuries</td>
</tr>
<tr>
<td>1934</td>
<td>15 Jan.</td>
<td>Bihar/Nepal</td>
<td>8,519</td>
<td>-</td>
</tr>
<tr>
<td>1837</td>
<td>17 Jan.</td>
<td>-</td>
<td>-</td>
<td>12,397</td>
</tr>
<tr>
<td>1833</td>
<td>26 Aug.</td>
<td>-</td>
<td>43</td>
<td>30</td>
</tr>
<tr>
<td>1823</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1810</td>
<td>May</td>
<td>-</td>
<td>Moderate casualties</td>
<td>Many buildings and temples collapsed</td>
</tr>
<tr>
<td>1767</td>
<td>June</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1681</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Many buildings and temples collapsed</td>
</tr>
<tr>
<td>1408</td>
<td>-</td>
<td>-</td>
<td>Heavy casualties</td>
<td>Many buildings and temples collapsed</td>
</tr>
<tr>
<td>1260</td>
<td>-</td>
<td>-</td>
<td>Heavy, Widespread famine and epidemic</td>
<td>-</td>
</tr>
<tr>
<td>1255</td>
<td>7 June</td>
<td>-</td>
<td>1/3 of total population including King Abhaya Malla Killed</td>
<td>Many buildings and temples collapsed</td>
</tr>
</tbody>
</table>
22. Building regulations in Nepal

The damage assessment of the earthquake of 1988 revealed that destruction of buildings was mainly due to poor construction and low level of awareness of code requirements and earthquake resistant technology among local communities. Consequently, the National Building Code (NBC) Development Project was formulated through the Department of Buildings assisted by UNDP (UNDP Project NEP/88/054). The 20-volume draft code with four levels of application were prepared in 1994. To enforce the NBC, the Building Act 1998 was promulgated, but unfortunately could not be enacted due to technical difficulties. The Department of Urban Development and Building Construction (DUDBC) further added three volumes to the code. The entire set consisting of 23 volumes was approved by the Government of Nepal (GoN) in 2003. The Code contains provisions pertaining to architectural, structural, mechanical and electrical requirements and the objective is to protect the public by accounting for the influence of the local conditions on construction.

The NBC was enforced through the Building Act 1998 (first amendment 2007) and Building Regulation 2008, and was approved by the government. Although it was applicable to the whole country and a legally binding document across all 130 municipalities, it was not mandatory for village development committees that existed before recent local level restructuring in Nepal. Only a few municipalities adopted the building code before the 2015 earthquakes. Lalitpur sub-metropolitan city was the first municipality in Nepal to implement the NBC in the Building Permit Process through a declaration on the Earthquake Safety Day celebration on 16 January 2003.

The National Building Code (NBC) presents regulations and guidelines for buildings to control and improve the seismic performance of buildings to meet an acceptable level of safety. The Code incorporates four different aspects of building types according to the complexity of design and construction (Table 6):

1. International state-of-the-art
2. Professionally engineered structures
3. Buildings of restricted size designed by simple rules of thumb
4. Remote and rural buildings where control is impractical.

**International state-of-the-art buildings**

These include buildings with complicated designs usually found in developed countries. The structures must comply with existing international state-of-the-art building codes. However, they must also meet Nepalese requirements with respect to minimum design load and configuration.

**Professionally engineered structures**

Buildings designed and constructed under the supervision of engineers, buildings with a plinth area more than 93 square metres, building having more than 3 storeys, buildings with a span more than 4.5 metres and buildings with irregular shapes fall into this category. It covers public buildings like hospitals, meeting halls, factories, multi-story buildings and larger residential buildings.
Mandatory rules of thumb

The mandatory rules of thumb can be used in the case of buildings that meet certain criteria related to height, number of storeys and floor area: may be used by the non-experienced builder and junior engineer to apply for a building permit and in the construction process.

The documents that cover the aspects of mandatory rules of thumb are:

- Mandatory Rules of Thumb Reinforced Buildings with Masonry Infill (NBC 201)
- Mandatory Rules of Thumb Reinforced Buildings without Masonry Infill (NBC 205)
- Mandatory Rules of Thumb Load Bearing Masonry (NBBC 202).

Guidelines for remote rural buildings

The guidelines focus on changes required to make buildings seismic-resistant, which are not subjected to modern quantitative analysis and rational design considerations. They include earthen buildings and low-strength buildings (unfired masonry, mud mortar, rubble, and dry stones). Documents included in this section are:

- Guidelines for Earthen Resistant Building Construction: Earthen Buildings (NBC 204)
- Guidelines for Earthen Resistant Building Construction: Low strength Masonry (NBC 203).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of Building Code</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>International State-of-the-art. Applicable codes: NBC 000</td>
<td>Applicable to large building structures. The structures must comply with existing international state-of-the-art building codes</td>
</tr>
<tr>
<td>2</td>
<td>Professionally Engineered Buildings</td>
<td>Buildings designed and constructed under supervision of engineers, buildings with plinth area more than 93 square metres, building having more than 3 storeys, buildings with span more than 4.5 metres and buildings with irregular shapes</td>
</tr>
<tr>
<td>3</td>
<td>Mandatory Rules of Thumb. Applicable codes: NBC 201, NBC 202, NBC 205</td>
<td>Buildings of a plinth area less than 93 square metres, less than 3 storeys, building having a span less than 4.5 metres and regular buildings designed and constructed by technicians in areas where professional engineers are not available</td>
</tr>
<tr>
<td>4</td>
<td>Guidelines for Remote Rural Buildings (Low Strength Masonry/ Earthen Buildings)</td>
<td>Buildings constructed by local mason in remote area and not more than 2 storeys</td>
</tr>
</tbody>
</table>
23. Building construction practices in Nepal

Since 2015 the NBC has become mandatory for every municipality and is enforceable. The main municipalities and also the village municipalities are bound to follow the NBC for new construction which includes the massive reconstruction after the Gorkha earthquakes.

The enforcement of the building codes in all the municipalities is ensured through the building permit system. The building permit is provided for construction of a building only when the design and drawings of the building fulfils the NBC provisions and by-laws and the building completion certificate is provided to demonstrate that the building is constructed as per the design and drawings. Municipalities such as Dharan have also implemented a reward-and-punishment system where contractors who do not build according to NBC compliant design and drawings will lose their license to work in their municipality. Furthermore, upon demonstration of good work the municipality rewards contractors during different events such as the Earthquake Safety Day. The same municipality has also introduced supervision of construction work with an additional charge of NRs. 5 per square ft (0.93 square metres). They also provide incentives to owners (50% discount in fee) when they apply for a permit to retrofit their existing buildings.

24. Research approach and methodology

Nepal has 205 new municipalities that have recent experience with the implementation of building codes while of the remaining 58 municipalities a few have already implemented the NBC. The selection of the case study area includes both the old municipalities (having a long experience of the implementation of building codes) and new municipalities (which have only recently started the implementation). A total of five municipalities were selected as part of the case study areas. Municipalities in the Kathmandu Valley - where the capital of the country is situated - were selected in addition to a small number of municipalities external to the Valley. The three municipalities in Kathmandu Valley were Lalitpur (first municipality to implement NBC), Thimi municipality and Budhanilkhanta municipality (new municipalities) (See figure 8). Two municipalities outside Kathmandu Valley were Dharan (implementation in 2007) and Duhabi (new municipality).

bb. Data Collection

The key stakeholders selected for the interviews were engineers and government officials working in the field of building code implementation and building construction, and politicians who play an important role in urban development and housing. A total of ten engineering professionals, one engineering academic and three politicians/administrators were interviewed.

cc. Details of interview participants

A total of 14 key stakeholders participated in semi-structured interviews. All the respondents are either directly or indirectly related to the NBC enforcement. Among the respondent 57% were from the age group of 31-50, 21.5% from 18-30 and 51-70 age group (Figure 22).
In terms of employment experience in the construction industry, 50% of the respondents had been working in the construction industry for more than 10 years. Those who had worked in the construction industry for 2-5 years were as equally represented as respondents who had worked in the industry for 6-10 years; both were 21.5% of the overall group, and the remaining 7% had less than 2 years’ experience (Figure 23). Of all of the respondents, 79% were engineers. (Figure 24). Most of the engineers interviewed, particularly in local government were involved in checking designs and building drawings for compliance to building codes and building by-laws, and providing approval for construction. In terms of length of experience in their current position, 21% had been there for less than 2 years, around half of the respondents had 2-5 years of working experience in the current position and 29% had been there for more than 5 years (Figure 25).
As for who the respondents were employed by, around 72% worked for local government, while 21% worked for the state and 7% for NGOs and private entities. Of these organisations, 29% worked in organisations with 50-100 staff, half (50%) of the respondents worked in an organisation with 101-500 staff, while 21% worked in an organisation with more than 500 people (Figure 26).
25. Results

dd. Participants’ perception on building compliance

Almost all the organisations that the respondents worked in observed the Earthquake Safety Day to raise awareness on the building codes. They also provided different levels of training such as mason training: many municipalities consider this form of training as one of their successful strategies to promote voluntary compliance. Some organisations also used megaphones and media channels for dissemination of information regarding NBC. The Dharan and Thimi municipalities have conducted house owner counselling every week for those who are interested in applying for a building permit (Figure 27). The state organisation has also developed a number of guidelines, construction specifications, pamphlets, and prototype designs. They provide training on safe building construction to different levels of technicians such as engineers, sub-engineers, assistant sub-engineers and masons.

For many key stakeholders, traditional settlements are common in their working areas and they noted difficulty in the implementation of building codes across these localities. On one hand, traditional construction technology has stood the test of time, however, on the other it has not been incorporated properly into the NBC. The NBC has focused and provided details more on new or modern technology, such as reinforced concrete. Furthermore, the highly dense traditional settlements have certain construction details and characters which the NBC has not been able to capture in detail.
ee. Reasons suggested by stakeholders for non-compliance of building codes

The key stakeholders pointed out a number of challenges in the compliance of the NBC, although all the respondents felt that the compliance has been more voluntary after the Gorkha earthquakes 2015.

Non-compliance of owners

- One of the biggest challenges is the lack of awareness of the owners regarding safety, the NBC and its compliance.
- Inner city areas where the land size is small and it has its own traditional technology and people with a weak economic background, the implementation of NBC is a challenge (Figure 28).
- Construction not undertaken under the supervision of skilled technicians due to economic constraints.

Figure 28.
Buildings in inner city areas, Nepal
Lack of experience of engineers

- Technicians do not have sufficient knowledge of designing especially in city centres where buildings such as high-rises are being constructed.
- Fresh graduates are unaware of the NBC.
- Awareness of the importance of NBC and its role in disaster resilience.
- Field implementation, especially of construction detailing such as lapping, stirrups, ties and other methods is problematic.

Government

- Inadequate institutional capacity (lack of skilled technical human resources).
- Lack of effective reward-and-punishment system.
- Political pressure to provide building permits or completion certificates, although the design and construction of a building lacks compliance to building codes.
- Gaps in the building permit system as the monitoring of the foundation is missing during the process of construction. Monitoring on the site is done below the damp-proof course (DPC) level where there is empty land and after above DPC.
- Strong political will to enforce building codes.

Issues with building codes

- The NBC has the limitation that it does not have clear instructions on steel structures.
- The MRT 205—which has been followed in several municipalities—has certain issues in that it does not consider practical aspects such as two ways eccentric, one-way eccentric, strap beam, combine foundation, and raft foundations.
- Ambiguity of MRT.
- Design of foundation when land is open from only two sides.

Other problems identified

- Quality of materials.
- Large stocks of old buildings exist, which were not built according to building codes and retrofitting them is challenging.
- Most of the respondents pointed out that awareness of all the stakeholders is the basic and key aspect to help encourage voluntary compliance. In Nepal, where most houses are owner-driven, it would be fruitful to develop incentive mechanisms for the house owners to encourage NBC compliance.
- Proper system in the municipality with less a less bureaucratic process.
- Political will to make the city safe.
26. **Key findings and recommendations**

The study has revealed a number of challenges and also recommended areas of improvement. It has outlined some major impediments to the compliance of NBC:

- Capacity development
- Awareness of different stakeholders
- Involvement of academia
- Need to find solutions on retrofitting of existing buildings
- Incentives.

27. **Future research opportunities**

The results obtained from the study point out that further studies can be conducted to find ways to formalise and standardise the construction of traditional technology (informal settlements). Research can also be conducted on different ways and means of raising awareness of different stakeholders, including politicians.
Figure 29. A building damaged by the 2015 Gorkha earthquakes in Nepal
3. Conclusions

28. Responses to research questions

The discussion of the results of the research is structured along the main research question and sub-questions (see 1.2.b). To begin with, the sub-questions are addressed, which then leads to an analysis of the findings pertaining to the main research question. The discussion is drawn from the preceding case studies and literature reviews.

ff. Responses to the sub-questions

Sub-question 1:

What are the strengths and weaknesses in terms of disaster resilience of building codes globally, and specifically in the project countries?

Some of the key issues below were revealed broadly in the global literature review, which were then further revealed in more detail in the case study contexts, discussed below under Sub-question 2.

- **Building regulations vs Building codes**: One of the key weaknesses is the lack of distinction between building regulations and building codes. Building codes and regulations are often used simultaneously, but their scope and meaning varies. ‘Building regulations’ usually refers to land use planning, setbacks and easements, building character, density, height, etc, which can be at the urban or settlement level. On the other hand, ‘building codes’ are specific to the design and construction of individual buildings, with technical building provisions or construction requirements to maintain certain standards of safety, human comfort and well-being.

- **Integration between Building regulations vs Building codes**: The other weakness is that the level of differentiation and integration between regulations and codes varies widely, both in developed and developing countries, making compliance and enforcement complex for achieving disaster resilience. For example, even if a building is built to high safety standards following codes, if it is allowed to be built in a vulnerable location, it may not be resilient to the impacts of disasters. Japan is one example where they are strongly integrated, which has been advantageous in minimising the impacts of disasters.

- **Mounting emphasis to act**: In many developing countries, building codes do exist but are often not mandatory. However, one of the strengths is that after the 2015 earthquakes in Nepal, there is stronger emphasis on implementation of the National Building Code. Another strength is in Bangladesh, at least in the new and formal urban developments, where there is an attempt to enforce building regulations; there are also claims by some builders that the National Building Code is followed.

- **Need for greater intervention**: Despite the mounting emphasis many challenges exist in terms of capacity, compliance and enforcement; there is very little in the way of building regulations in Nepal. There is a similar situation in Bangladesh, where typically, at the national level and even at the wider urban level, both the building regulations and codes are disregarded, and in many cases, there is little knowledge of them even among built environment professionals.
Figure 30. Informal sector buildings range from slum dwellings to brick-and-concrete buildings, as seen from these photos from Bangladesh (above) and Nepal (below)
In the two project countries a wide range of stakeholders were interviewed, including from the public and private sectors, academia, built environment professionals and construction workers. The insights gained from these interviews are discussed earlier in the case studies, and the key challenges can be summarised along the following key lines:

- **Large Informal sector**: The widespread and proliferating informal sector in both project countries where building codes and regulations are not followed (Figure 30). In Nepal, there is an attempt to contextualise building codes for small buildings and those built out of traditional materials (e.g. earth, low-strength masonry), but there is no such effort in Bangladesh, where the building codes pertain to buildings constructed out of formal sector materials such as concrete and brick; thus, there is little relevance of the codes for the informal sector. In addition, there is a large existing building stock, mostly built informally and some of the buildings quite old and deteriorating, and the inhabitants there are particularly at risk (Figure 31). There is hardly any exploration on how this risk might be addressed. The formation and existence of the informal sector is fuelled by the challenges discussed below.

- **Lack of awareness and knowledge**: This was a key challenge in promoting compliance to building codes. Although building codes exist in both the countries, there was widespread lack of awareness about it and knowledge on how to understand and apply it, spanning from built environment professionals to construction workers. Codes are often understood as bringing resilience only to earthquakes, not the wide range of hazards in these countries; indeed, particularly in Nepal, the building codes deal primarily with earthquakes and not interpreted for other hazards. Such awareness and knowledge comprise a prerequisite to compliance; without knowing the codes or fully understanding them, one cannot be expected to comply to them.

- **Lack of capacity**: This is related to the above issue – knowledge is an essential basis for building capacity in interpreting, implementing and complying with building codes. Once again, this capacity building need is at all stakeholder levels from formally trained built environment professionals to informal sector construction workers.

- **Perception of extra cost**: Incorporation of building codes does incur an extra expense, but this is not significant if their long-term safety and disaster resilience benefits are considered. In the project countries, building codes are widely perceived as costly and hence avoided, without any serious cost-benefit analysis presented by professionals or demanded by building owners.

- **Corruption**: This is a key challenge in promoting compliance to building codes and building regulations. In Bangladesh where building regulations (or bye-laws) are somewhat enforced in the more affluent and formal sector buildings, there are reports of violation in the wider context; building codes are by and large ignored, if known at all. In Nepal, even when there is an institutional drive to implement building codes, there is a tendency to avoid them wherever possible. Political patronage and bribery are some of the key corruption instruments.
Although at this time the challenges outweigh the opportunities, the opportunities below were drawn from the interviews:

- **Institutional initiatives:** Recent disasters in the two countries, namely the Rana Plaza garment factory collapse in Bangladesh and the 2015 earthquakes in Nepal brought institutional focus on the importance of building codes. In Bangladesh, the key urban regulatory body, RAJUK, has embarked on a building resilience program supported by the World Bank. Similarly, in Nepal, there is strong international support to promote building codes and the government has mandated the implementation of building codes, which provides an opportunity for promoting compliance.

- **Educational initiatives:** Although not yet at the level as required, there are some initiatives to include education on building codes at the tertiary level. In Bangladesh, only in the curricula of the premier engineering university, BUET, building codes has been included, but perhaps it is the beginning for more widespread uptake. In Nepal, the Institute of Engineering in the premier educational institution, Tribhuvan University, is spearheading education on building codes, and again, can be a basis for replication by other educational institutions.

- **Awareness and capacity building:** Although Bangladesh is lagging behind current international approaches, there are quite a few initiatives in Nepal to build awareness and capacity - the ‘Earthquake Safety Day’ is celebrated in a significant manner and serves as a vehicle for raising awareness on safe construction practices. Training of masons in safe construction is beginning to be done widely in Nepal, a way of building capacity at that level which has relevance for the informal sector. There is the opportunity for Bangladesh to learn from these initiatives.
Figure 31. Old and deteriorating buildings in Kathmandu, Nepal; note how the buildings are buttressed to prevent toppling
Sub-question 3:
What practice-and-policy guidelines are required to facilitate voluntary compliance and implementation of safe building codes?

Practice-and-policy guidelines relevant to the two project countries were discussed earlier in the case studies. Here some of the key elements, relating to the challenges and opportunities discussed above under Sub-question 3, are drawn out.

- **Increasing Awareness:** Strong and widespread initiatives on building awareness at all levels is required. Although some initiatives in this regard have been identified above, there is scope for a much more concerted and extensive effort. Policies for doing so can be implemented in partnership between public, private and civil society actors, and can be upscaled for the wider community level.

- **Professional bodies reinforcing codes in education:** Policies should be targeted for capacity building on building codes at all levels ranging from incorporation of knowledge on building codes in tertiary level education of built environment professionals to training of construction workers. The “Grey Building Handbook” produced in this project is an initiative in this direction and can serve as a training manual for informal sector builders.

- **Financial incentivisation for compliance:** A range of policy instruments, indicated particularly in the Bangladesh case study context, and to some extent in the Nepal case study, including financial incentives, ‘reward-and-punishment’, and regulatory code of professional practice could move forward the building codes compliance agenda. Coupled with awareness on the importance of building codes for disaster resilience, it could be the basis for more widespread voluntary compliance.

- **Formation of new authorities/institutions:** From the investigations in Bangladesh, it was found that the need for a specific authority for implementation and enforcement of building codes was expressed. RAJUK in Bangladesh is primarily involved in approving building permits and monitoring of construction relating to building regulations and there is no agency for building codes implementation. However, RAJUK with the support of the World Bank has embarked on a new program for implementation of building codes, and perhaps this is an opportunity for integration of regulations and codes under one authority.

- **More integrated and targeted guides:** In Nepal on the other hand, the Ministry of Urban Development oversees implementation of building codes, primarily relating to earthquake resilience, and there is limited focus on building regulations. There is thus scope here for integration of codes and regulations, as well as building codes dealing with a wider range of hazards.
29. Responses to the main research question:

How can compliance to voluntary safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased disaster resilience?

The discussions around the research sub-questions provide pointers to addressing the main research question. In order to do that, it would be useful to broadly categorise buildings into two sectors, formal (a relatively small proportion in the national contexts of the two project countries, and indeed throughout South Asia, but because of the large population, and growing prosperity and aspirations, significant in absolute terms) and informal (the majority of buildings in the two countries, ranging from rudimentary slum dwellings to brick-and-concrete multi-storey buildings). Various approaches were suggested in the interviews and literature to catalyse voluntary compliance such as incentives, tax benefits, reduced insurance premiums and reverse mortgage, inclusion in educational curricula and school buildings, contextualised approach according to country, sector-wide training including construction workers and informal builders, and perhaps most importantly, raising awareness. A mixture of such strategies in varying extents in the formal and informal sectors as discussed below can be way forward in addressing the above research question.

gg. Formal sector

In the major cities in Bangladesh and municipalities in Nepal, there are already initiatives for implementing building codes and regulations in the formal sector, although as yet there is a gap in the coverage and also reports of violation and corruption. The suggestions discussed above relating to capacity building, financial incentives, education and enforcement (fines, rewards, monitoring of practitioner licensing, etc) pertain to the formal sector as mechanisms for promoting voluntary compliance, and there are already some small beginnings of voluntary implementation of codes in some municipalities in Nepal and by some real estate developers in Bangladesh. These examples can be a basis for upscaling voluntary compliance initiatives.

hh. Informal sector

Raising awareness is the main pathway to achieving voluntary compliance in the informal sector. The key issue is that many of the building codes in developing countries have been adapted from developed countries, but having significantly lower resources and weaker governance, the codes prove difficult to implement in the socio-economic conditions of the developing world. A large part of the population in the project countries live in informal settlements and rural areas, and the high building standards specified in the codes are simply not feasible.

Building codes specify a wide range of design and construction guidelines and standards to enable safety, health and comfort for users and occupants of buildings, where the safety aspects are the most crucial to protecting human lives and well-being from disaster impacts. Therefore, in the developing world context where lack of resources and other factors are barriers to implementing a comprehensive array of building codes, to begin with this most basic and critical life-saving element makes sense and signifies building standards that specifically address disaster resilience. Thus a ‘Grey Building Handbook’ (see appendix) derived from the research and contextualised for Bangladesh and Nepal
comprises one of the main outputs of this project, where a suite of safe building options is presented to match different incomes and site conditions.

The approaches in Nepal, such as specific codes for traditional and small buildings and training of masons, address the safety needs of the large informal sector. While there is scope for upscaling these approaches in Nepal, there is also opportunity for Bangladesh to gain lessons, and contextualise and implement such approaches.

30. Conclusions

The overarching goal of this project was to undertake research on approaches and options for promoting voluntary compliance to safe building codes for disaster resilience, focusing on two case study contexts – Bangladesh and Nepal. A secondary, though equally important, goal was to develop a handbook that would enable practitioners, local builders and construction workers in low-income communities to begin the process of building disaster resilient buildings, which would eventually help them to move towards compliance to a wider gamut of building codes. Although these goals were focused on the two project countries, their outcomes have relevance for the wider region and other developing countries with similar conditions and hazard vulnerability.

The project has revealed valuable lessons on the resonance of the findings of the literature review and empirical investigations. The similarity of findings in the two project countries indicate the nature of the problem being essentially related to issues of governance, institutional and technical capacity, and public awareness. Nonetheless, despite the similarities, there were lessons unique to each country, providing an opportunity for sharing of lessons through collaborative research and the considerable benefits that can arise from knowledge sharing and the cross-fertilisation of expertise and ideas.

Experience from the project has shown that the engagement of a wide range of project stakeholders in both countries has helped raise awareness of the building codes issue. Compliance to building codes is a complex issue, yet the signs uncovered of growing awareness and initiatives indicate that disaster resilience through widespread voluntary compliance of safe building codes and regulations is a possibility that might be realised over time in the future.

4. Future Directions

This project pointed to further research directions to broaden the understanding of the multi-faceted topic of building codes compliance, which includes:

- Developing options for retrofitting or strengthening old buildings, following to the extent possible the construction standards as prescribed in the building codes of the respective project countries.
- Stakeholder and policy mapping for better understanding of possible roles in the integration of building codes and building regulations.
- Exploration of community perceptions of risk and willingness for voluntary compliance, and the incentives and policy environment required for it.
• Developing methods of raising public awareness and the channels and stakeholders that might be effectively involved for that purpose.

• Understanding the role of social media in how it might be utilised to promote widespread compliance to building codes and regulations.

• Investigation of the role of the private sector, and how effective partnerships can be forged between the public and private sectors, and civil society.
5. References


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UNESCAP United Nations Economic and Social Commission for Asia and the Pacific; Asian Institute of Technology. (2012). Integrating Environmental Sustainability and Disaster Resilience in Building Codes. Bangkok: UNESCAP.


6. **Appendices**

i. List of early career researchers.

ii. Introductory workshop agenda.

iii. Interim workshop agenda.

iv. Final workshop agenda.

v. CIFAL website report on project workshop.

vi. Journal paper based on the project.


### Appendix i: List of early career researchers involved in the project.

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Key Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Josephine Vaughan, Casual Academic</td>
<td>UoN</td>
<td>Research Assistant; final report production support</td>
</tr>
<tr>
<td>Ms Georgia Kissa, PhD Scholar</td>
<td>UoN</td>
<td>Research Assistant; ‘Grey’ Building Handbook production support</td>
</tr>
<tr>
<td>Ms Oluwadunsin Ajulo, Scholar</td>
<td>UoN</td>
<td>Research Assistant; global literature review support</td>
</tr>
<tr>
<td>Mr Shaiful Islam Bhuiyan, Engineer</td>
<td>DU</td>
<td>Research Assistant; data collection and country report production support</td>
</tr>
<tr>
<td>Ms Inu Pradhan-Salike</td>
<td>TU</td>
<td>Research Assistant; data collection and country report production support</td>
</tr>
</tbody>
</table>
Appendix ii: Introductory workshop agenda

INTRODUCTORY WORKSHOP
Kathmandu, Nepal, 8-10 November 2017

“Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal.”

A research project funded by the Asia Pacific Network for Global Change Research (APN)

Project partners: University of Newcastle, Australia; Dhaka University/BRAC University, Bangladesh; Tribhuvan University, Nepal.

| AGENDA |
|-----------------|-----------------|
| **Day 1: 08/11/17** | **Day 2: 09/11/17** |
| 08:30 – 09:00 | 08:30 – 09:00 |
| Registration | Scope of Day 2 |
| 09:00 – 09:15 | Dr Ifte Ahmed |
| Welcome speech | **Day 3: 10/11/17** |
| 09:15 – 09:30 | 09:00 – 09:30 |
| Introductions/Scope of workshop | Bangladesh |
| 09:30 – 10:00 | 09:30 – 10:00 |
| Project Overview | Nepal |
| 10:00 – 10:30 | 10:00 – 10:30 |
| Introduction to the Disaster & Development Research Group, University of Newcastle | Bangladesh |
| 10:30 – 10:45 | 10:30 – 10:45 |
| Break | Break |
| 10:45 – 11:15 | 10:45 – 11:15 |
| Introduction to the Disaster Research Training & Management Center (DRTMC), Dhaka University and Postgraduate Programs in Disaster Management, BRAC University | Bangladesh |
| 11:15 – 11:30 | 11:15 – 11:30 |
| Introduction to the Centre for Disaster Studies, Tribhuvan University | Nepal |
| 11:30 – 12:15 | 11:30 – 12:15 |
| State of building codes for disaster resilience in Nepal | Nepal |
| 12:15 – 12:30 | 12:15 – 12:30 |
| General discussion; planning for the next days | Bangladesh |
| Lunch | Lunch |

Country groups present key literature and initiatives on building codes in respective countries.

| Country groups present key stakeholders for interviews and/or project plan |
|-----------------|-----------------|
| Day 3: 10/11/17 | **Day 2: 09/11/17** |
| 09:00 – 09:30 | 09:00 – 09:30 |
| Australia | Australia |
| 09:30 – 10:00 | 11:00 – 11:30 |
| Bangladesh | Australia |
| 10:00 – 10:30 | 11:30 – 12:00 |
| Nepal | Bangladesh |
| 10:30 – 10:45 | 12:00 – 12:30 |
| Break | Nepal |
| 10:45 – 11:00 | 12:30 – 13:00 |
| Introduction to scope of empirical investigation | Lunch |
| 11:00 – 11:30 | 12:30 – 13:00 |
| Country groups present key stakeholders for interviews and/or project plan | Field visit to reconstruction sites |
## Appendix iii: Interim workshop agenda

### AGENDA

**Day 1: 23/04/18 – Public Event**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Speaker(s)</th>
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<tbody>
<tr>
<td>0830 – 0910</td>
<td>Registration</td>
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<tr>
<td>0910 – 0930</td>
<td>Welcome speech</td>
<td>Prof Humayun Kabir</td>
</tr>
<tr>
<td>0930 – 0950</td>
<td>Introduction/ Scope of workshop/ Project Overview</td>
<td>Dr Iftikhar Ahmed</td>
</tr>
<tr>
<td>0950 – 1010</td>
<td>Introduction to the Disaster &amp; Development Research Group, University of</td>
<td>Dr Iftikhar Ahmed</td>
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<tr>
<td></td>
<td>Newcastle</td>
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<tr>
<td>1010 – 1030</td>
<td>Key results of a Global Literature Review on Building Codes and Disaster</td>
<td>A/Prof Thayaparan Gajendran</td>
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<tr>
<td></td>
<td>Resilience</td>
<td></td>
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<tr>
<td>1030 – 1045</td>
<td>Break</td>
<td></td>
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<tr>
<td>1045 – 1115</td>
<td>Introduction to the Centre for Disaster Studies, Tribhuvan University</td>
<td>Dr Hari Danshan Shrestha</td>
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<tr>
<td></td>
<td>Key results of Field Investigations on Building Codes and Disaster</td>
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<tr>
<td></td>
<td>Resilience in Nepal</td>
<td>Dr Hari Danshan Shrestha and Ms Inu</td>
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<td></td>
<td>Research Center, Dhaka University and Postgraduate Program on Disaster</td>
<td>Pradhan-Salike</td>
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<tr>
<td></td>
<td>Management, BRAC University</td>
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<td></td>
<td>Key results of Field Investigations on Building Codes and Disaster</td>
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<tr>
<td></td>
<td>Resilience in Bangladesh</td>
<td>Prof Humayun Kabir and Mr</td>
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<td></td>
<td>Shaful Islam Shabuys</td>
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<tr>
<td>1145 – 1215</td>
<td>Keynote: State of building codes for disaster resilience in Bangladesh</td>
<td>Engr Abdul Latif Holaly</td>
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<tr>
<td>1215 – 1245</td>
<td>Fire Accidents, Building Collapse and Rescue Operations in Bangladesh</td>
<td>Major A K M Shahid Nawaz</td>
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<tr>
<td>1245 – 1300</td>
<td>Open discussion</td>
<td>Moderated by Dr Iftikhar</td>
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<tr>
<td></td>
<td></td>
<td>Ahmed and Prof Humayun Kabir</td>
</tr>
<tr>
<td>1300 – 1400</td>
<td>Acknowledgements/ Note of thanks</td>
<td>Prof Humayun Kabir</td>
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<td></td>
<td>Lunch</td>
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**Day 2: 24/04/18 – Internal Workshop**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Speaker(s)</th>
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<tbody>
<tr>
<td>0900 – 0930</td>
<td>Scope of Day 2</td>
<td>Dr Iftikhar Ahmed</td>
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<tr>
<td></td>
<td>Country groups present plans for next stages of the project</td>
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<tr>
<td>0930 – 1000</td>
<td>Nepal</td>
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<tr>
<td>1000 – 1030</td>
<td>Bangladesh</td>
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<td>1030 – 1045</td>
<td>Break</td>
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<tr>
<td>1045 – 1115</td>
<td>Australia</td>
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<tr>
<td>1115 – 1230</td>
<td>Workshop on project issues: financial, reporting, publications, long-term</td>
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<td></td>
<td>plans, etc.</td>
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<td>1230 – 1330</td>
<td>Lunch</td>
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**Day 3: 25/04/18**

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<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>0900 – 1230</td>
<td>Field visit (Rana Plaza, Savar Adjacent Areas)</td>
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</table>
### Appendix iv: Final workshop agenda

**FINAL WORKSHOP**

Main Hall, Institute of Engineering, Tribhuvan University, Pulchowk Campus, Lalitpur, Nepal  
28-30 August 2018

"Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal"

A research project supported by the Asia Pacific Network for Global Change Research (APN)  
Project partners: University of Newcastle, Australia; Dhaka University/BRAC University, Bangladesh; Tribhuvan University, Nepal.

#### AGENDA

<table>
<thead>
<tr>
<th>Day 1: 28/08/18 - Public Event</th>
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<tr>
<td>08:30 – 09:00</td>
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<td>09:00 – 09:15</td>
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<td>12:45 – 13:00</td>
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<td>13:00 – 14:00</td>
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<tr>
<th>Day 2: 29/08/18 - Internal Workshop</th>
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<tr>
<td>09:00 – 09:30</td>
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<th>Day 3: 30/08/18</th>
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<td>09:00 – 12:30</td>
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</table>
Appendix vi: CIFAL website report on project workshop

vi. Journal paper based on the project.
Compliance to building codes for disaster resilience: Bangladesh and Nepal

Iftekhar Ahmed*, Thayaparan Gajendran, Graham Brewer, Kim Maud, Jason von Meding and Jamie MacKee

Abstract

This paper reports on a project that explores the opportunities and challenges for compliance with safe building codes for disaster resilience, focusing on two countries - Bangladesh and Nepal. Recent disasters in both countries highlight a significant problem of non-compliance with building codes. However, these disasters have brought institutional and community awareness of the importance of safe building codes, presenting a germane opportunity to explore the issues associated with compliance. Building codes do exist in the two countries, but due to socio-economic, political and cultural conditions compliance is generally lacking or limited, particularly in the large informal building sector. There is thus a need for understanding how these codes might be more widely adopted to enable disaster resilience. Collaboration between partner universities in these countries with experience in this field address: sharing the understanding that evidence-based knowledge is a critical component in the commitment to local action; improving institutional and community awareness of the importance of compliance with barriers to enforcement of codes; fostering communities of collaborative practice; and developing local and international dissemination networks. A log-frame approach indicates the rationale, assumptions and expected outcomes of the project. The project is at a preliminary stage and this paper discusses the framework associated with the exploration of barriers and enablers to building codes compliance.

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Keywords: Building codes; Bangladesh; Nepal; Disaster resilience; Compliance.

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E-mail address: Ifte.Ahmed@newcastle.edu.au
1. Introduction

This paper reports on a project that explores the opportunities and challenges to compliance with safe building codes for disaster resilience, focusing on two countries in South Asia - Bangladesh and Nepal. The generation of scientific knowledge on building codes and construction continues apace globally, but its application to disaster risk reduction and resilience-building is lacking. South Asia is a case in point because land-use and building code frameworks are generally inadequate in low-income countries, such as the case study countries in this project. The bulk of buildings are constructed informally; rough estimates indicate that over 80% of housing in these two countries is informal [1][2]. There is very little or no application of building codes in informal sector construction. Even in the very small proportion of formal sector housing, adherence to building codes are generally lacking or limited at best. Building codes are not well-integrated into construction and planning regulations. Bangladesh and Nepal have building codes [3][4], but enforcement and compliance face significant challenges; the codes serve mainly as good practice guidelines. It is up to professionals, builders or authorities to follow them. Recognising the significance of this issue, the authors developed a research project to examine this situation, which was awarded a research grant from the Asia Pacific Network (APN) for Global Change Research. The project has recently been initiated, so this conference presents an opportunity to seek feedback on the project’s research framework.

2. Knowledge relating to safe building codes

The world is continually being barraged by disasters; in the recent decade there were more than 6,300 recorded disasters, of which close to half occurred in Asia [5], a continent with a large number of developing countries where disaster impacts are the most severe. Globally, governments, international development agencies and many organisations are taking disasters and the need for resilience seriously, reflected in the approval by the United Nations member countries of the Sendai Framework for Disaster Risk Reduction (SFDRR) [6]. The SFDRR, within its wider global resilience agenda, clearly articulates the importance of safe building codes: “To encourage the revision of existing or the development of new building codes and standards” [6] is a priority in the framework. A nother recent international commitment through the United Nations, the Sustainable Development Goals (SDGs) [7], has targets that recognise the importance of disaster risk reduction [8]. One of these targets is to “Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials” – and building codes would definitely be a vehicle for achieving this target. In the global ‘Resilient Cities Campaign’ of the United Nations Office of Disaster Risk Reduction (UNISDR), a key element is to “Apply and enforce realistic, risk compliant building regulations and land-use planning principles” [9]. Prominent international development agencies such as the World Bank, United States Agency for International Development (USAID) and Japan International Cooperation Agency (JICA) have begun to address this global priority for resilient buildings and are promoting the uptake, compliance and implementation of safe building codes [10][11][12].

Building codes have been defined widely, but for the sake of this research project the definition by a notable dictionary - “A collection of regulations adopted by a city to govern the construction of buildings” [13] - helps illustrate a key point. Clearly this definition, and by extension this approach to building codes, relates to developed countries where building codes and building regulations are integrated into the legislative environment whereby enforcement provisions mandate compliance (see for example, the Australian National Construction Code in [19]). The broader term ‘building regulations’ as in developed countries includes both land-use planning and building codes [14]. This integration enables minimising the impacts of disasters, as evident from Japan, which has “… some of the world’s most stringent building codes” [15], but it is also pointed out that that it took more than seven decades, and a series of disasters, for Japan to arrive at this stage [16]. However, this is obviously not the case in many developing countries where building codes are often not mandatory (see for example, [17]); for example, in an earlier version of the Bangladesh National Building Code (BNBC), it is stated that, “… the Building Code is not an independent legislation or act, rather it is a national level approved document …” [18]. It is widely reported that enforcement and compliance of building codes face serious barriers related to governance and resource constraints, among other such factors [17][19][20][21][22][23], resulting in vulnerability to disasters.

A key issue is that many of the building codes in developing countries have been adapted from developed countries [12], but having significantly lower resources and weaker governance, the codes prove difficult to implement in the
socio-economic conditions of the developing world. A large part of the population lives in informal settlements and rural areas, and the high building standards specified in the codes are simply not feasible [16][19]. Building codes specify a wide range of design and construction guidelines and standards related to safety, health, amenity and sustainability (see for example, [24]), where the safety aspects are the most crucial to protecting human lives and well-being from disasters. Indeed, the earliest versions of building codes were mainly concerned with this aspect and they were gradually expanded to include a wider set of issues [25][26]. Therefore, in the developing world context where lack of resources and other factors are barriers to implementing a comprehensive array of building codes, to begin with this most critical life-saving element makes sense, termed here as ‘safe building codes’ to signify building standards that specifically address disaster resilience. This term is not indicated widely in the literature, but there is a recent “Safe Building Code Incentive Act” in the USA through which the government allocates extra funding for enforcing building codes in a disaster affected or prone context [27]. The term has been adopted here to reflect the specific approach of this project to prioritise disaster resilience in buildings to avoid or minimise loss of human lives and assets. In line with the concept of “grey literature” as a non-commercial publication [28], a ‘grey’ handbook contextualised for Bangladesh and Nepal will comprise one of the main outputs of the project, where a suite of safe building options will be presented to match different socio-economic, demographic and geographical conditions. The lead author produced a similar document in the past to guide housing in flood-prone areas of Bangladesh [29], and the handbook in this project will build on such initiatives for a wider range of hazards and environments.

It is widely cited that disasters present an opportunity for building future resilience [17][30][31][32]. Many country-specific guidelines and initiatives for safer buildings have arisen after major disasters (for example [33][34]). In the project countries, Bangladesh and Nepal, recent massive disasters have been triggers for institutional reconsideration of the importance of building code compliance. In Bangladesh after recent building collapses, particularly the collapse of the Rana Plaza garment factory in 2013 killing and injuring many people [35], the Bangladesh National Building Code (BNBC) has been reviewed and updated, and there are moves to make it mandatory and enforced through a new regulatory authority [36]. However, the problem persists that a large bulk of buildings are built informally without permits, hence codes are difficult to enforce within the current context.

Similarly, in Nepal after the huge number of deaths and injuries in the 2015 earthquakes and destruction of more than 250,000 buildings [37], building codes have gained significant institutional attention. The National Building Code (NBC) has been revised and it is being publicised by the government that strict measures will be applied to implement it [38]. The NBC was originally developed after a great earthquake in 1988 [39], but was followed in only very few municipalities [38]; whether it will now be more widely adopted is yet to be seen. Nonetheless, there is greater international attention and local commitment evinced at this time, perhaps the early beginning of wider acceptance and compliance, which could be supported by awareness and education.

It is therefore a relevant time for research on this topic. This project thus explores ways of achieving wider implementation of safe building codes, not only in the formal sector through regulatory enforcement, but also in the wider informal building activity through voluntary compliance. Compliance is not only about development and enforcement of regulations, but a social transformation where organisations and communities appreciate the benefits of safe codes and follow them willingly (e.g. [40]), aptly termed by Johnson [19] as a “compliance culture”. Various approaches are suggested to catalyse such a paradigm shift, such as incentives, tax benefits, reduced insurance premiums and reverse mortgage [17], inclusion in educational curricula and school buildings [19], contextualised approach according to country [41], sector-wide training including construction workers and informal builders [42], and perhaps most importantly, raising awareness [24]. This project examines such approaches in the context of the emerging initiatives on implementation of building codes to identify prospects for wider promotion and application for disaster resilient building practices.

3. Context of the case studies

It is understandable that developing countries such as Bangladesh and Nepal face constraints in implementing building codes. Beyond the oft-cited issues of enforcement and corruption, affordability is a key constraint for the vast bulk of the population that build informally. The codes provide a broad spectrum of good practice guidelines, often based on developed country models, and can thus be onerous and difficult to implement in their entirety in the socio-economic context of South Asia. However, the codes also include guidelines for safety to enable buildings to be
disaster resilient – these hazard-related codes can be termed as ‘safe building codes’ to differentiate them from codes that deal with other aspects (see for example [27]). At a bare minimum, if only the safe building codes are followed, a level of disaster resilience can be achieved.

Fig. 1. Lack of compliance to safe building codes makes the rapidly growing cities in Bangladesh (a) and Nepal (b) vulnerable to disasters.

Both the project countries face disaster risk from various types of hazards including earthquakes, floods, windstorms and landslides. Nepal endured severe earthquakes recently in 2015, where the common adage “Earthquakes don’t kill people, buildings do” [43] was visibly and tragically apparent. Although Bangladesh has not experienced a major earthquake in recent times, strong tremors are frequently felt, creating public fear [44]; a massive earthquake is a real and significant possibility. Bangladesh is also frequently affected by floods and cyclones, most recently in 2016 by Cyclone Roanu [45]. Both these countries are also severely threatened by climate change with increasing magnitude and frequency of disasters. New types of hazards such as extreme heat and cloudbursts [46][47] are likely to exacerbate the impact of disasters. The avoidance of building regulations and the lack of adherence to building codes mean that it does not always require a natural hazard to result in a disaster – the collapse of the Rana Plaza garment factory in Bangladesh in 2013, killing more than 1,100 mainly women garment workers and injuring another 2,500, illustrates this point [35].

The devastating, and high-profile, disasters mentioned above including the Nepal earthquakes and Bangladesh building collapse have raised local awareness on the importance of safe buildings. They have spurred significant institutional and community interest and activity in both these countries on disaster resilient construction and safe building codes, in the face of public fear and anxiety, reported in personal communications with people there. It does appear that there might be an opportunity for voluntary compliance to safe building codes beyond the necessity of policing and institutional enforcement. It is reported that some municipalities in Nepal and some real estate developers in Bangladesh are voluntarily following building codes [48][49], representing a gradual paradigm shift. It is therefore a relevant and opportune time to undertake this project with the purpose of exploring the research problem relating to understanding the opportunities and challenges of facilitating compliance to safe building codes.

4. Relevance to policy processes

Disaster resilience is of high-level policy concern in both Bangladesh and Nepal because of the frequent and various disasters that affect these countries. Bangladesh is one of the few countries in the world that has a Ministry of Disaster Management and Relief dedicated to disaster risk reduction and has a key policy instrument in this regard, the ‘National Plan for Disaster Management’ (2016-2020) [50]. Nepal has a Disaster Management Section in the Ministry of Home Affairs and has established key policy instruments recently including the National Strategic Action Plan for Disaster Risk Reduction (2017 - 2030) and the National Disaster Risk Reduction Policy 2017 [51].

The NSDRM specifically highlights the importance of building codes for disaster risk reduction. However, in Bangladesh the issue of building codes is dealt with by RAJUK (Capital Development Authority) under the Ministry of Housing and Public Works, and although there are recent concerns there regarding building codes for disaster resilience, it is not coordinated with the national disaster management policy. There is thus the possibility of facilitating coordination between policies for disaster risk reduction and safe building practice, which this project will be able to facilitate. In terms of safe building codes, both governments require significant and extensive inputs in
translating their policy instruments on the ground particularly to address the widespread informal sector and addressing potential disaster impacts and resilience strategies for at-risk communities. Thus, the timing and scope of this project is relevant to both country contexts as policymakers and national institutions are faced with the challenges of implementing, mainstreaming and rolling out nationwide policies. It is also opportune because of recent commitments made by both countries to the global SDG.

5. Research Framework

The research problem is complex, multi-faceted and deeply entrenched in socio-economic, political and cultural conditions and has grown over a long period of time. Addressing it would require social transformation of a profound nature, and currently perhaps only the small beginnings of such transformation are evident. Thus, this project is a form of ‘process research’. The research question and sub-questions below are therefore not expected to provide quick-fix and easy solutions, but to identify a probable and plausible trajectory for the small beginnings of social transformation that may realise a greater and more widespread voluntary compliance of safe building codes over the long term.

5.1. The avenue of inquiry

Given the widespread lack of compliance to building codes in the case study countries of Bangladesh and Nepal and consequent disaster impacts leading to a growth of interest in safe building codes, a key research question arises, which is exploratory in nature:

How can compliance to voluntary safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased disaster resilience?

The following sub-questions are framed to deliver an answer to the main research question:

- What are the strengths and weaknesses in terms of disaster resilience of building codes globally, and specifically in the project countries?
- What knowledge and insights can be gained from institutional and community stakeholders in the project countries on opportunities and challenges for facilitating compliance to safe building codes?
- What practice-and-policy guidelines are required to facilitate voluntary compliance and implementation of safe building codes?

5.2. Exploratory methodological approach

The project methodology is linked to the main research question and sub-questions discussed. The main research question - “How can compliance to voluntary safe building codes be facilitated in the current contexts of Nepal and Bangladesh for increased disaster resilience?” is exploratory in nature in line with definitions of exploratory research, for example, “... an examination into a subject in an attempt to gain further insight” [52] and “... the researcher’s tool to understand an issue more thoroughly” [53]. However, to seek answers to the question, a set of sub-questions are posed, that are descriptive and will allow discovery of the nature and characteristics of the phenomenon explored by the main research question. The descriptive studies will be of mixed-method, that is, they will employ a range of empirical methods including case studies, interviews, focus group discussions and workshops, utilising participatory and consultative data collection tools. Stakeholder consultations in the project countries and project workshops will be the prime vehicles for employing these methods and tools. The empirical part of the project will be substantial, informed by and positioned within global and local knowledge streams. An exploratory global literature review will cast a wide net to capture inter- and transdisciplinary perspectives.

5.3. Logical anticipation of outcomes

A ‘log frame’ (abbreviated from logical framework) was used to plan this project; this enabled providing an overview of the project’s goals, activities and anticipated results in a matrix. This matrix structure specified the components of the project and the measures by which the anticipated results will be monitored. One of the key aspects of the matrix was to elicit the assumptions made in delivering each goal or activity.
The log frame was aligned to the below five objectives of the project:

i. A review of global literature and local literature in the project countries including building codes and regulations to identify potentials and gaps in terms of disaster resilience;

ii. Develop an understanding of challenges and opportunities for facilitating voluntary compliance to safe building codes;

iii. Produce practice-and-policy guidelines for facilitating voluntary compliance and implementation of safe building codes extending to informal sector buildings;

iv. Involve early career researchers in the project countries to meet the above objectives and thereby build local research capacity;

v. Explore possibilities of forming networks and cross-learning between the project countries and wider regional and international knowledge dissemination.

### Table 1. Log frame for objective 2.

<table>
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<td>Develop an understanding of challenges and opportunities for facilitating voluntary compliance to safe building codes;</td>
<td>A minimum of 20 participants will involve in data collections consultations in Nepal and Bangladesh. Ensure at least 5 stakeholder groups are involved (NGO's, Government and building owners)</td>
<td>UoN will have regular meetings (Skype) with BRAC, University- Bangladesh and Tribhuwan University, Nepal to work through the data collection process</td>
<td>The stakeholders are willing to participate and they have adequate understanding of the issues and working around building codes.</td>
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<td>Identity at least 5 key opportunities and 5 key challenges in facilitating voluntary compliance to safe building codes in project countries</td>
<td>The stakeholders will be given the findings to verify the outcomes.</td>
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<td>Outputs</td>
<td>Two 30 pages reports on opportunities and challenges each for Bangladesh and Nepal. Report will identify stakeholders who are best to address the challenges and opportunities</td>
<td>Submission of the reports to relevant authorities/stakeholders</td>
<td>The relevant stakeholders who were part of the workshops will support addressing the issues and exploiting the opportunities.</td>
</tr>
</tbody>
</table>

### Activities/Process

- **Activity 1:** Organizing consultation workshops
  - At least three consultation events and 10 interviews will be organized with different stakeholders
  - UoN will monitor the data collection
  - Stakeholders are keen to participate and share their experiences

- **Activity 2:** Analyzing data collected through consultations/interviews and producing a report
  - NU 1.0 will be used to analyse the data with identifying appropriate codes
  - The product of data analysis will lead to a code book and subsequent abstractions will identify at least 5 opportunities and challenges
  - Attendance numbers to the workshop
  - The literature has specific information about the key issues to identify gaps and perform a systematic literature review.

- **Activity 3:** Disseminate the research findings to build a case for a policy-practice guide
  - Organize two workshops with at least 10 members from the key stakeholder groups
  - The consultation will lead to in-depth discussions on issues relating to voluntary code adoption

### Means/Input

**Activity 1:**
- Data collection assistants in Bangladesh and Nepal
- Venue for consultation, catering, audio recorders
- Compliance to project budget
- Performance targets for project assistance in terms of searching material
- The participants can be recruited with reasonable effort. Can find appropriate venues for consultations

**Activity 2:**
- Project team members and project/data collection assistants
- NU 1.0 software
- 1. Number of reference in the electronic form (Minimum 200) 2. Analysis sheets
- The consultation will lead to in-depth discussions on issues relating to voluntary code adoption

**Activity 3:**
- Four project team members, projectors, catering and venue for the workshops
- There will be no unforeseen circumstances impacting on the workshop

For example, as shown in Table 1, objective 2 will deliver a detailed account of the challenges and opportunities in facilitating voluntary compliance of safe building codes in Bangladesh and Nepal. The indicators to assess its results will be identification of at least 5 key opportunities and 5 key challenges in facilitating voluntary compliance to safe building codes in project countries. The verification will be through the stakeholder feedback and endorsement. The key assumptions include that the stakeholders are willing to participate and they have adequate understanding of the issues and working around building codes. The log frame further goes to identify the outputs and three activities supporting the outputs, each of them with specific verification indicators and assumptions. Such a log frame approach...
was applied to all the above five objectives to formulate a detailed operational methodology.

5.4. Capacity development for the long term

Capacity development is an important element in this project in a number of ways. Firstly, it aims to produce guidelines informed by safe building codes that will be applicable for training of local construction workers and informal sector builders, and more broadly of personnel of government agencies and NGOs involved in the disaster resilience field. Secondly, early career researchers will be engaged in all three project countries - Australia, Bangladesh and Nepal - providing a valuable capacity building opportunity through working on this regional and also international research project. And thirdly, the involvement of CIFAL Newcastle, which itself has a strong capacity development agenda, will mean that the project outcomes will be utilised for wider training and exchange of learning. CIFAL Newcastle is engaged in other capacity building initiatives in several countries in the Asia-Pacific region, therefore the findings of this project will support regional capacity building beyond the project countries. Additionally, the World Bank will support a regional workshop to disseminate the project results, which will also promote and contribute to regional capacity strengthening initiatives.

6. Conclusion

This project is situated at a complex crossroads, where nations aspire for building codes of international quality yet contain a predominance of informal settlements. Such settlements also continue to proliferate. Genuine resilience will require these countries to develop an augmented building regulation capacity (both in terms of codes/advisory documents, and implementation/compliance), and an acceptance that this will require an extended period of execution. Informal settlements will require special sensitivity in terms of political, social and economic factors, where affordability to comply with building codes plays a vital role so that efforts do not further disadvantage the most vulnerable.

Consideration will be required as to the balance between regulatory advice, policing and enforcing compliance where appropriate, and providing well-informed good practice advice for those constructing with vernacular materials and skills, where enforcing compliance could be counter-productive. Ultimately this project is intended to inform the development of such materials, and protocols for their dissemination, which would ultimately be likely to utilise the "training of trainers" model. Such an approach has great potential as the most appropriate method of increasing capacity, across diverse topics and sectors, in low-income communities.

Acknowledgements

This paper is based on a research project funded by the Asia Pacific Network for Global Change Research under its Collaborative Regional Research Programme.

References

Acknowledgements

A "training of trainers" model.

5.4 was applied to all the above five objectives to formulate a detailed operational methodology.

Secondly, early career researchers will be engaged in all three project countries.

The involvement of CIFAL Newcastle, which itself has a strong capacity development agenda.


Iftekhar Ahmed  et al. / Procedia Engineering 212 (2018) 986–993
Compliance to building codes for disaster resilience: Bangladesh and Nepal

International Conference on Building Resilience 2017, Bangkok

School of Architecture and Built Environment
Faculty of Engineering and Built Environment
University of Newcastle, Australia
Acknowledgements

• This paper is drawn from a research project “Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal”, Sept 2017 – Aug 2018.

• Supported by a Collaborative Regional Research Programme (CRRP) grant from the Asia-Pacific Network for Global Change Research (APN).

• Collaborators: Bangladesh - University of Dhaka and BRAC University (Prof Humayun Kabir, Dr Mohammad Faruk); Nepal - Tribhuvan University (Dr Hari Darshan Shrestha, Mr Nagendra Sitoula).
Research Problem

• Bangladesh and Nepal - bulk of buildings (>80%) constructed informally.
• Even in formal sector, limited adherence to building codes.
• Codes are not well-integrated into building and planning regulations.
• Building codes exist, but enforcement and compliance face challenges.
• Beyond enforcement and corruption, affordability is a key constraint for people who build informally. Need for a ‘grey’ building code.
• ‘Safe building codes’ - if only they are followed, a level of disaster resilience can be achieved.

• “Earthquakes don’t kill people, buildings do”.

• Human-induced – e.g. Rana Plaza in Bangladesh.

• Increased institutional and community awareness about building safety - opportunity for voluntary compliance to safe building codes.

• Already a gradual paradigm shift - relevant time for this project.
Rationale for Context Focus

- South Asia - low economic and human development; least developed region after Sub-Saharan Africa; highly vulnerable to disasters.
- Disaster impacts in the smaller SA countries are pronounced and recovery difficult compared to India. Thus the focus here.
- Transfer of lessons and cross-learning, also be valuable for the region.
- Another ongoing project in Sri Lanka, plans to work in the Maldives.
- Long-term plan – produce a book on disaster resilience in the smaller SA countries.
Global Frameworks

- Bangladesh and Nepal - bulk of buildings (>80%) constructed informally.
- Globally, governments, international development agencies and many organisations and institutions are taking disaster resilience seriously: HFA to SFDRR.
- A priority in SFDRR: “To encourage the revision of existing or the development of new building codes and standards”.
- SDGs: “Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials”.
- UNISDR ‘Resilient Cities Campaign’: “Apply and enforce realistic, risk compliant building regulations and land-use planning principles” (UNISDR, 2010).
- Prominent international agencies eg World Bank, USAID, JICA, promote uptake, compliance and implementation of safe building codes.
Regulations: Basic Categories

- **Prescriptive regulations:**
  
  - Standards created to be basis for how buildings should be constructed.
  - Specifies materials, configurations and processes required to achieve the desired regulatory goal.

- **Performance-based regulations:**
  
  - Uses in-use performance of buildings as basis for building activities.
  - More flexible approach where only the desired regulatory goal is specified.
Developed vs Developing Countries

- In developed countries building codes and building regulations are integrated – include both land-use planning and building codes.
- Integration enables minimising disaster impacts, eg Japan, but took more than 70 years and a series of disasters to get to this stage.
- In most developing countries building codes are often not mandatory or limited to cities and the formal sector.
- Widely reported that enforcement and compliance of building codes face serious barriers related to governance and resource constraints, among other such factors, resulting in disaster vulnerability.
Safe Building Codes

• Building codes in developing countries have been adapted from developed countries.
• With significantly lower resources and weaker governance, codes prove difficult to implement in developing world socio-economic conditions.
• Large slum populations and rural areas, high building standards not feasible.
• Building codes specify guidelines and standards for safety, health and comfort; safety aspects are most crucial to protect from disasters.
• Earliest versions mainly concerned with safety and then expanded.
• In developing countries to begin with this most basic and critical life-saving element makes sense (‘safe building codes’).
• Not wide in literature, but recent “Safe Building Code Incentive Act” in USA - government allocates extra funding for enforcing building codes in a disaster affected or prone context.
• Term adopted here to prioritise disaster resilience in buildings.
‘Grey’ Building Codes

• “Grey literature” - form of non-commercial publication.

• A ‘grey’ handbook derived from the research and contextualised for Bangladesh and Nepal will comprise one of the main outputs of the project.

• Suite of safe building options will be presented to match different incomes and environmental conditions.

• Development of building codes that a suitable for the countries’ social and economic conditions and promotes the use of local materials.
Barriers

• Weak incentives and implementation mechanisms.
• High compliance costs.
• Lack of manpower.
• Insufficient fund.
• Institutional bottlenecks.
• Corruption.
• Dysfunctional regimes and governance.
• Lack of awareness.
Opportunities

• Provision of consistent construction standards.
• Safe construction and durability of building stock.
• Psychological safety against risks.
• Proper basis and guideline for insurance services.
• Cost-effective solution to building construction.
Compliance

- Two major and conflicting philosophies address the issue of compliance:
  - **Deterrence** approach uses severe sanctions and increased cost for non-compliance.
  - **Facilitation** approach reduces the cost for compliance to allow for voluntary compliance.

What is a facilitator?

- Literally means: ‘*making things easy*’
- A person who **helps** a group or team to:
  - Achieve results in interactive events
  - By using a range of skills and methods
  - To bring the best out in people as they work together
  - Focus on the process of **how**
Voluntary Compliance

- Widely cited that disasters present opportunity for building resilience eg “Build Back Better”.
- The problem is that a large bulk of buildings built informally without permits, hence codes cannot be enforced.
- Therefore a different approach is required to promote disaster resilience.
- Compliance is not only about development and enforcement of regulations.
- Social transformation where organisations and communities appreciate the benefits of safe codes and follow them voluntarily - “compliance culture”.

“|

It was worse than guilty! — The jury found me noncompliant!”

—— CartoonStock (www.cartoonstock.com)
Possible Approaches

• Various approaches are suggested:
  ✓ Incentives;
  ✓ Tax benefits;
  ✓ Reduced insurance premiums/reverse mortgage;
  ✓ Inclusion in educational curricula and school buildings;
  ✓ Contextualised approach according to country;
  ✓ Sector-wide training including construction workers/informal builders;
  ✓ Raising awareness.
Possible Strategies

- Human Resources: Capacity building of professionals and officials.
- Enforcement Capacity: Institutional capacity to balance punitive measures with incentives.
- Cooperation among stakeholders: GO, NGO, private sector, community – participatory approach.
- Risk zonation: Restricting development in hazard zones and providing alternatives.
Bangladesh

- In Bangladesh and Nepal, recent massive disasters have been triggers for institutional reconsideration of the importance of building codes.

- In Bangladesh after recent building collapses eg Rana Plaza (2013) the Bangladesh National Building Code (BNBC) has been reviewed and updated.

- There are moves to make it mandatory and enforced through a new regulatory authority. However, only in formal sector buildings.

- Even if small proportion of buildings, still a beginning and can be the basis to further extend the safe building codes agenda.
Nepal

- Huge number of deaths and injuries in the 2015 earthquakes and destruction of more than 250,000 buildings.
- Building codes have gained significant institutional attention.
- National Building Code (NBC) revised and government states that strict measures will be applied to implement it.
- Developed after 1988 earthquake, followed in only few municipalities.
- Now greater international attention and local commitment.
Research Framework

• Main question:
  How can compliance to voluntary safe building codes be facilitated in the current contexts of Bangladesh and Nepal for increased disaster resilience?

• Sub-questions:
  ✓ What are the strengths and weaknesses in terms of disaster resilience of building codes globally, and specifically in the project countries?
  ✓ What knowledge and insights can be gained from institutional and community stakeholders in the project countries on opportunities and challenges for facilitating compliance to safe building codes?
  ✓ What practice-and-policy guidelines are required to facilitate voluntary compliance and implementation of safe building codes?

• Not expected to provide easy solutions - small beginning of social transformation that may realise more widespread voluntary compliance of safe building codes over the long term.
Objectives & Outcomes

• Review global literature and local literature in the project countries including building codes and regulations to identify potentials and gaps in terms of disaster resilience.

• Engage in consultations with key stakeholders at institutional and community levels to understand challenges and opportunities for facilitating voluntary compliance to safe building codes.

• Produce practice-and-policy guidelines for facilitating voluntary compliance and implementation of safe building codes extending to informal sector buildings.

• Involve early career researchers in the project countries to meet the above objectives and thereby build local research capacity.

• Explore possibilities of forming networks and cross-learning between the project countries and wider regional and international knowledge dissemination.
## Log Frame Approach

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Project Planning Workshop, Kathmandu, Nov 2017
Steering the Crossroads

- Introductions between project partners and developing collaboration.
- Situated at a complex crossroads - aspiration for international quality building codes yet predominance of informal settlements.
- Balancing augmented building regulation capacity with sensitivity for informal settlements.
- Perhaps a "training of trainers" approach - great potential for increasing capacity across diverse topics and sectors, in low-income communities.
Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia

grey
BUILDING HANDBOOK
the cases of Nepal and Bangladesh

Supported by a Collaborative Regional Research Programme (CRRP) grant from the Asia-Pacific Network for Global Change Research (APN)
UNDERSTANDING THE OPPORTUNITIES AND CHALLENGES OF COMPLIANCE TO SAFE BUILDING CODES FOR DISASTER RESILIENCE IN SOUTH ASIA
the cases of Bangladesh and Nepal

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Supported by a Collaborative Regional Research Programme (CRRP) grant from the Asia-Pacific Network for Global Change Research (APN)

Design of the handbook, texts and drawings by Georgia Kiss, Research Assistant, University of Newcastle Australia.
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PREFACE

This handbook has been produced in the Collaborative Regional Research Project “Understanding the opportunities and challenges of compliance to safe building codes for disaster resilience in South Asia - the cases of Bangladesh and Nepal” supported by the Asia Pacific Network for Global Change Research (APN). The project is led by the University of Newcastle, Australia, in partnership with Dhaka University and BRAC University in Bangladesh, and Tribhuvan University in Nepal.

The world is continually being barraged by disasters, often with the most severe impacts in developing countries. Poor populations living in unregulated settlements in these countries are disproportionately harmed and their informally constructed houses tend to be highly vulnerable. Building and land use regulation can prove to be a remarkably powerful tool for increasing people’s safety and resilience and limiting the risk that they face. However, many of the building codes in developing countries have been adapted from developed countries, but having significantly lower resources and weaker governance, the codes prove difficult to implement in the local socio-economic conditions.

It is therefore relevant to explore ways of achieving wider implementation of safe building codes, not only in the formal sector through regulatory enforcement, but also in the wider informal building activity through voluntary compliance.

To support this process, this ‘grey’ handbook has been produced, contextualised for the local context and achievable within the socio-economic constraints of developing countries. It includes a set of options to meet varying economic and environmental conditions and extensively uses visual material for ease of communication and comprehension. The handbook is targeted primarily for the informal building sector and is expected to support capacity building at the community level.

THE PROJECT

This project explores the opportunities and challenges to compliance of safe building codes for disaster resilience in South Asia, focusing on two countries of the region, Bangladesh and Nepal. Recent disasters in both countries highlight that the problem lies in non-compliance to building codes. Building codes do exist in the two countries, but compliance is generally lacking or limited, especially in the widespread informal building sector. There is thus a need for understanding how these codes might be more widely adopted to enable disaster resilience. Collaboration between universities in these countries with experience in this field addressed this need.
NEPAL

Nepal is characterized by a rugged topography, high relief, variable climatic conditions, with complex geological features. Furthermore, it lies in the tectonically active zone. Nepal faces risk from various types of hazards including earthquakes, floods, windstorms and landslides, and has experienced numerous disasters. The impacts of disasters are enhanced due to human activities such as unplanned urbanization and inadequate construction of buildings and infrastructure. Nepal endured severe earthquakes in 2015 when many buildings collapsed, killing the people inside them.

BANGLADESH

Bangladesh is one of the world’s most vulnerable countries to natural hazards and climate change. The primary threats to Bangladesh are floods and cyclones, and earthquakes and fires pose significant risk in the rapidly growing unplanned urban areas. The avoidance of building regulations and the lack of adherence to building codes mean that it does not always require a natural hazard to trigger a disaster - the collapse of the Rana Plaza garment factory in Bangladesh in 2013, killing more than 1100 mainly women garment workers and injuring another 2,500, illustrates this point.
THE HANDBOOK

This handbook provides advice, guidance and necessary information on key issues associated with building in disaster-prone areas and for the planning, siting, design and construction of housing with improved resilience to common and recurrent hazard events. It is targeted for local builders and homeowners in Bangladesh and Nepal, to promote principles of safe design and construction. It aims to minimize vulnerability to hazards, so that houses will safeguard occupants and their assets. Since many construction concepts are not easy to describe, the handbook contains illustrations of good practice to facilitate understanding and to explain how to build better.

HOW TO USE THE HANDBOOK

The judgment, experience and choice of the implementer or user would play an important role in deciding which combination of FOUNDATION, POST, WALLS and ROOFING would be suitable, thus allowing flexibility in house design user participation.

This handbook can also serve as a training manual, where the trainer should facilitate discussion among stakeholders to decide upon appropriate house designs based on assessment of the different construction options for the main parts of a house provided here.

The tables below has been prepared to assist in this process.
BUILDING STEPS

PLANNING

Before considering to build a house it is necessary to ascertain the suitability of the location and its environment.

TOPOGRAPHY
- elevation, slope, undulations, drainage,
- ground condition

SUBSOIL CONDITIONS
- drainage paths, waterways, wetlands, coastline,
- canals or streams

ACCESSIBILITY
- access to roads and related ground stability issues,
- communication and routes for evacuation

SHAPE
- select simple symmetrical shapes which minimize development of tension effects.
- Square and rectangular shapes are preferable.

FOUNDATION

The function of a building foundation is to support the building safely distributing all the loads acting on the structure including the weight of the building and foundation, live loads and external loads to the ground.

Foundation shall therefore be designed to:
1. contain any settlement in the ground with tolerable limits
2. have sufficient strength and rigidity to undergo significant deformation
3. be stable and durable
**CORE**

The core of the house suitable for structural loads, prevent from external conditions, provide ventilation and light.

**TYPE 1**
R.C. concrete frame with brick walls

**TYPE 2**
load bearing brick walls

**TYPE 3**
timber frame with earth blocks or other infill

**ROOF**

The roof may be constructed as a pitched roof with corrugated sheets or tiles as the roofing material or as a flat roof with a reinforced concrete slab.

**TYPE 1**
R.C. reinforced concrete

**TYPE 2**
timber framing with CI sheets/tiles
CONSTRUCTION OPTIONS

A
FOUNDATION
- continuous footing

B
POSTS
- R.C. Post timber

C
WALLS
- brick
- concrete block
- earth block
- lightweight infill
- bamboo

D
ROOFING
- RC slab
- timber frame with CI sheets / tiles
- rainwater gutter
01_ PLANNING

The form, degree of exposure, quality of construction, degree of structural integrity of the basic design all influence behavior of buildings under high wind stress.
Tall buildings offer some protection to lower buildings during cyclonic wind.
Site planning in cyclone-prone areas should take into consideration possibility of using tall buildings as wind breaks.
Tall buildings can be the cause of wind eddies, reverse local winds, gusts and wind shadow suction areas.
Sheltered sites reduce exposure to wind hazards. Avoid building near steep edges and steep sided valleys opening onto the sea.
Avoid linear-type development because wind forces through straight, open and parallel channels and increases in speed: “wind-tunnel effect”.

A steeply pitched roof receives high wind loading and may blow in.

Well-constructed buildings which are not well-anchored down to their foundations may overturn.

A low pitched roof receives high suction and may blow off.

Buildings without well-connected stiffened joints may distort.

A 30° pitched roof receives least wind stress.

Building shielded by vegetation placed at distance equal to tallest wind-break tree at full growth and built upon raised plinth is well-protected against wind and flood.
The choice of site for a building is mainly concerned with the stability of the ground as well as to avoid the full force of the wind or flood. Simple rectangular shapes behave better in an earthquake than shapes with projections. Torsional effects of ground motion are pronounced in long narrow rectangular blocks. Therefore, it is desirable to restrict the length of a block to three times its width. If longer lengths are required two separate blocks with sufficient separation between should be provided.

Separation of a large building into several blocks may be required so as to obtain symmetry and regularity of each block. Embankment to protect the area from cyclone storm surge and wave uprush. Rocks placed on seaward side to break wave strength. Other side to be planted with trees with deep roots to bind soil and prevent erosion. Cyclonic effect may persist inland, especially through river estuaries. May lead to flooding, therefore need for flood-proofing with emergency evacuation route and shelter zone / refuge area.
02_Foundation

Continuous

Mixture of earth and cement to create a typical earthen plinth.
The proportion of cement should be at least 5%.
3 weeks curing by water should be done.
footing

COLUMN FOOTING
• Independent footing provided under a column.
• Distributes concentrated loads uniformly to the soil.
• Square, rectangular or circular in plan.
• Depending upon load and bearing capacity of soil, footing can be of brick or stone masonry, RC, etc.

WALL FOOTING & RC FOOTING
• Several courses of bricks, lowest course twice the wall thickness above.
• 5 cm offset to achieve widened base; each course 1 brick thick, in some cases bottom courses 2 bricks thick.
• Bed of lean concrete, 15 cm deep minimum, projection on each side 10-15 cm; depth of bed should not be less than its projection beyond base wall.
• Concrete bed provides a plain surface to start the wall footing; rectifies inequalities of excavation and bridges over soft patches in the soil below.
• RC footing if heavy load and bearing capacity of soil is low; otherwise massive structure is needed and would be uneconomical.
• 7-8 cm lean concrete bed below RC footing.
TYPES OF FOOTINGS

TIMBER/ BAMBOO POSTS

CONCRETE/ BRICK POSTS
03_ POSTS

RC. concrete posts

1. The proportions of the concrete mix are usually kept “1 : 2 : 3” or “1 : 2 : 4” by volume of “cement : sand : aggregate”.
2. The reinforcement may be any of the following: a) Mild steel and medium tensile steel bars. b) High strength deformed steel bars.
3. All reinforcement should be free from loose rust and coats of paints, oil, mud or any other substance which may destroy or reduce bond with concrete. Use four steel 15mm diameter re-bars, tied together with 6mm diameter stirrups and 8-10inch normal spacing.
4. Square post shape at least 20x20cm and distance between them not more than 3m.
5. Concrete frame needed to bond the walls and used as a base for the roof. Otherwise a roof slab could function as well.
6. Perimeter concrete banding on top of openings.
04__WALLS

Load bearing walls

Masonry strengthened by mild steel bars, hoop iron, expanded mesh or bars. Resistant to tensile, compressive and shear stresses.
Ability to resist lateral forces: seismic and cyclonic areas.
For long walls without junctions or openings, reinforced sections constructed at intervals <1.2m for hollow block, 2.0m for solid block walls.
15-25 cm cover around reinforcement for corrosion prevention.
Also reinforced brick columns and floor slabs.
Concrete strip footings for masonry walls with reinforcing bars at every corner and intersection between walls, each corner of doors and large openings and intermediate positions <1.2m apart.
reinforced masonry

Masonry walls must be reinforced at all corners and junctions and sides of doors and window openings. Strengthening masonry buildings against earthquakes by providing horizontal and vertical reinforcement.
**timber frame**

Stud-wall construction consists of timber studs and corner posts framed into sills, top plates and wall plates. Horizontal diagonal braces are used to stiffen the frame against lateral loads due to earthquake and wind. The wall covering may consist of matting made from bamboo, reeds, and timber boarding or the like.

1. The dimension of the sill is 90 x 90 mm, 90 x 90 mm or larger. The sill is connected to the foundation by anchor bolts whose minimum diameter is 12 mm and length 350 mm. The anchor bolts are installed at both sides of joints of sills and at the maximum spacing is 2 m.

2. The minimum nominal dimension of studs is 40 x 90 mm. The maximum spacings of these studs vary from 0.5 to 1. If studs are 40 x 90 then spacing should be 0.5 m, if 90 x 90 mm studs are used the spacing may be doubled, but the interior or exterior linings might need to be thicker.

3. Storey height should not be more than 2.7 m. For 2 storey houses studs should be placed every 0.5 m.

4. The tops of studs are connected to top plates whose dimension is not less than the dimension of the stud.

5. Wall framing consisting of sills, studs and top plates should have diagonal braces, or sheathing boards so that the framing acts as a shear or bracing wall. In case no sheathing boards are attached, all studs should be connected to the adjacent studs by horizontal blockings at least every 1.5 m in height.
05_ ROOF : BASIC PRINCIPLES

**aerodynamic roof form**
1. Roof pitch 30-40 degrees to reduce effects of suction and uplift.
2. Hipped instead of gable roof. If gable, then end tied down firmly to rest of structure. Lean-to should be avoided.
3. Overhang < 2'-6", verts in roof and masonry parapet.
4. RC roof provides superior protection. Need for adequately braced.

**roof connected to structure**
1. Rafters at recommended spacing
2. Cross bracing in plane of roof and ceiling.
3. Strong connections between roof and vertical structure. Metal straps, bolts with washers on both ends instead of simple nails.

**well-fixed roof covering**
1. CI sheet screwed at every corrugation. Tiles fastened individually.
2. Use of J-hook bolts and threaded / twisted roofing nails.

**regular maintenance**
1. Should make regular checks, especially around ridge and corners
2. Replace weakened members and repair loose members.
3. CI sheets should be tied strongly to structural frame to resist uplift by strong wind.

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**SHAPES OF ROOF**

- **hipped roof**
- **gable roof**
- **lean-to roof**
timber frame structure

Pitched roofs with adequate slope (+25 degrees) shall be provided in order to minimize uplift forces acting on the roof structure and to provide proper drainage of rainwater.
1. Maximum overhang should be 600mm.
2. Timber used in the roof structure shall be hardwood treated with an appropriate wood preservative.
3. Roofing elements should be connected properly: purlin to rafter, rafter to wall plate, wall plates to posts.
4. Every sheet to be fixed to purlins with hook bolts or twisted nails at each corrugation. More frequent fixings at edges to prevent uplift.
HIPPED ROOF

CONTINUOUS-RUNNER

PURLIN

RAFTER

ADDITIONAL PURLIN

MAXIMUM 3m DISTANCE BETWEEN POSTS

CONCRETE FLOOR SLAB
metal structure

- CI SHEETS
- KING POST
- MS ANGLE
- RAFTER
- TIE BEAM
- RAINWATER GUTTER
- MS FLAT BAR BRACKET
Supported by a Collaborative Regional Research Programme (CRRP) grant from the Asia-Pacific Network for Global Change Research (APN)
দক্ষিণ এশিয়ায় দুর্যোগ সহনশীল ও নিরাপদ ভবন নির্মাণ বিধানালার সম্পাদনা এবং অন্তর্যাম

নেপাল ও বাংলাদেশ

এশিয়া প্যাসিফিক নেটওয়ার্ক ফর গ্রোবাল চেঞ্জ রিসার্চ (এপিএন)-এর অনুসারে এবং কোলাবরিটিভ রিজিওনাল রিসার্চ গ্র্যাম (সিআরআরপি)-এর সহযোগিতায়
দক্ষিণ এশিয়ায় দুর্যোগ সহনশীল ও নিরাপদ ভূবন নির্মাণ বিধিমালার সমস্তাবনা এবং অন্তরায় নেপাল ও বাংলাদেশ

ফুল অব আর্কিটেকচার এন্ড বিল্ট এনভায়রনমেন্ট
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মি. নাদমু সিলোলা

দক্ষিণ এশিয়ার প্যাসিফিকনেটওয়ার্ক ফর গ্রোৰল চেঞ্চ নেটওয়ার্ক (এপিএন) এর
অনুষদে এবং কোলাবরেটিভ রিজিওনাল রিসার্চ প্রোগ্রাম (সিআরএস) এর
সহযোগিতায়

নির্দেশিকায় নকশা, লেখা এবং অক্ষ, জজিয়া কিসা, গবেষণা সহকারী,
নিউক্যাসেল বিশ্ববিদ্যালয়, অস্ট্রেলিয়া
সূচীপত্র

ভূমিকা

১. মুখবক্ত ৪
২. প্রকল্প ৪
৩. নেপাল ৫
৪. বাংলাদেশ ৫
৫. নির্মাণ শিশিকা ৬
৬. ব্যবহারবিধি ৬

নির্মাণ কাজ

১. নির্মাণ ধাপ ৭
২. নির্মাণের বিকল্পসমূহ ৯
৩. পরিকল্পনা ১০
৪. ভিত্তি ১৩
৫. বুটি ১৬
৬. দেয়াল ১৮
৭. ছাদ ২৩
মুখবন্ধ

“দক্ষিণ এশিয়া দুর্যোগ সহায়ী ও নিরাপদ ভবন নির্মাণ বিভিন্নলা সঙ্গাবনী এবং অন্তর্যাত্মক” শীর্ষক এই নিম্নলিখিত কোনটির ভিত্তিতে রিসার্চ প্রক্ষেপ এর অধীনে এবং এশিয়া প্যাসিফিক নেটওয়ার্ক ফর রোকলার চেয়ে নেটওয়ার্ক (এপিএন)-এর সহযোগিতায় তৈরি। এই প্রকল্পটি অস্ট্রেলিয়ার নিউক্যাসেল বিশ্ববিদ্যালয়ের নেতৃত্বে পরিচালিত। সহযোগিতায় রয়েছে বাংলাদেশের ঢাকা বিশ্ববিদ্যালয়, একাদিগুলো বিশ্ববিদ্যালয় এবং নেপালের মিত্র বিশ্ববিদ্যালয়।

বর্তমান পৃথিবী সংবিধিতভাবে নানা দুর্যোগ বাধাগ্রহণ হচ্ছে। উন্মুক্তশিল দেশগুলোতে এসব দুর্যোগের প্রভাব অত্যন্ত প্রকট। এসব দেশের অনিয়ন্ত্রিতভাবে গড়ে ওঠা বসতিভূমি বিনিয়োগের মানুষেরা বিভিন্নভাবে ক্ষতির সম্ভাবন হয়। বিশেষকরে, কোন নিয়ম অনুসরণ না করে গড়ে ওঠা ভবনগুলো অত্যন্ত বৃদ্ধির হয়। ভবন নির্মাণ এবং ভূমি ব্যবহার নীতিমালা জনগণের নিরাপত্তা এবং স্থিতিশীলতা ব্যবহার শক্তিশালী হিসেবে কাজ করে।

উন্মুক্তশিল দেশের অনেকের, ভবন নির্মাণ বিভিন্নলা উন্নত দেশ থেকে নেওয়া হয়েছে। কিছু সীমিত সমস্যা এবং দুর্লভ প্রশাসন ব্যবস্থার জন্য স্থানীয় অর্থসামর্থ্য প্রকল্পে নীতিমালার প্রয়োগ বেশ দুর্দ হয়।

সুতরাং, নিরাপদ ভবন নির্মাণ বিভিন্নলা বৃহত্তর ক্ষেত্র প্রয়োজনের পথ অসংবিধায় করা যথেষ্ট প্রাসঙ্গিক প্রয়োজন কেবলমাত্র অনুশীলন বা প্রথাগত জায়গায় সীমাবদ্ধ না রেখে অপ্রাশ্ন্তক ক্ষেত্রগুলোতেও রেচাঁ সম্মতির মাধ্যমে প্রসারিত করা একাত্ত প্রয়োজন।

এই প্রতিষ্ঠান সহযোগিতা করার উদ্দেশ্য সাধারণ নিদেশকা তৈরি করা হয়েছে যাতে মূল্য প্রস্তাপ এবং উন্মুক্তশিল দেশের অর্থ-সামর্থ্য প্রতিষ্ঠানকর সাধে সম্পন্ন সামঞ্জস্যপূর্ণ বলে ধরা যায়। বিভিন্ন অর্থসামর্থ্য ও পারিবেশিক অবস্থার প্রক্ষেতে নানা বিভিন্নলা/লক্ষ্যের মাধ্যমে অসংবিধায় অনুসারণ যোগাযোগ করার জন্য এতে নানা ধরনের বিকল্প ব্যবস্থার সম্প্রতিভ করা হয়েছে। অপ্রাশ্ন্তক নির্মাণঘটনা বর্তমান নির্দেশিকার প্রধান লক্ষ্য এবং গোষ্ঠী পর্যায়ে সামগ্রী বৃদ্ধি এর উদ্দেশ্য।

বর্তমান প্রকল্প

বর্তমান প্রকল্পটি দুর্যোগ সহায়ী দক্ষিণ এশিয়া গড়ে তোলার উদ্দেশ্যে ভবন নির্মাণের সহায়তা এবং অন্তর্যাত্মক অনুষ্ঠানের উদ্দেশ্যে গৃহীত। এই প্রকল্পটি দুটি দেশকে কেন্দ্র করে তৈরি হয়েছে, ভারত এবং নেপাল। দুটি দেশের সাম্প্রতিক দুর্যোগগুলো পর্যালোচনা করলে দেখা যায় যে, ভবন নির্মাণ বিভিন্নলা না মেনে চলার মধ্যেই মূল সমস্যা নিহিত। দুটো দেশের ভবন নির্মাণ বিদ্যমান রয়েছে কিন্তু কোনো সীমিত ক্ষেত্রেই তা মেনে চলা হয়। বিশেষকরে বিভিন্ন ভালো কৃতি কোনো বিভিন্নলা ভালো কৃতি লক্ষ্যের অর্থসামর্থ্য। এজন্য দুর্যোগ সহায়ী ভালো কৃতি ভালো কৃতি নিয়মনীতির ব্যাপক ব্যবস্থার নিয়োগ চালু করা যায় তা অনুমান করা হয়। এই উদ্দেশ্যেই বিভিন্ন দেশের বিশ্ববিদ্যালয়ের মধ্যে সহযোগিতার মাধ্যমে সংযোগ স্থাপন করা হয়েছে।
নেপাল

নেপাল বন্দুক ভূমিরূপ, সুউচ্চ ভূমিক্ষপ, বৈচিত্র্যময় জলবায়ু এবং জটিল ভূতাত্ত্বিক বৈশিষ্ট্যের দেশ। তাহারা, এটি ভূপালনিকভাবে সম্পৃক্ত অঞ্চলে অবস্থান। এদের নেপাল ভূমিক্ষপ, বন্যা, ঝাঁপ, এবং ভূমিক্ষপ সহ বিভিন্ন ধরনের বিপর্যয় বুঝিতে রয়েছে এবং ইতিমধ্যে অসংখ্য দুর্যোগের সমৃদ্ধীনও হয়েছে। অপরিকল্পিত লপ্তবায়ু এবং অপরিকল্পিত নির্মাণের মত মনুষ্য সৃষ্ট কর্মকান্দের দরকার দুর্যোগ পরিবর্তী ক্ষয়ক্ষতি ঘটতে হচ্ছে। ২০১৫ সালে নেপাল ভাবে ভূমিক্ষপের সমৃদ্ধীন হয় যার ফলস্বরূপ বহু সংখ্যক ঘরবাড়ি ধ্বস পড়ে এবং হতাহতের ঘটনা ঘটে।

বাংলাদেশ

বাংলাদেশ, প্রাকৃতিক দুর্যোগ এবং জলবায়ু পরিবর্তনের দরকার সবচেয়ে বৃহত্তর দেশগুলোর মধ্যে অন্তর্ভুক্ত। বাংলাদেশের জন্য প্রাথমিক হামক হিসেবে বিবিধ বন্যা, ঝুঁতি, ভূমিক্ষপ এবং অগ্নি দূর্ঘটনা, বৃহৎ বর্ষামুল্লাল অপরিকল্পিত নবনির্মাণের কারণে উল্লেখযোগ্য সমস্যা সৃষ্টি করছে। গুরুত্বরবৃদ্ধি নীতিমালার প্রতি অবদান এবং উদাসীনতার অর্থ হলো দুর্যোগ সংকটের ক্ষেত্রে কেবল মাত্র প্রাকৃতিক বিপর্যয়কে কারণ হিসেবে চিহ্নিত না করা। ২০১৩ সালে রানা পাক্ষা ধর্মীয় ঘটনা পূর্বে দূর্ঘটনার বর্তমানের অর্থ হলো দূর্ঘটনার ঘটনা ১১০০ জনেরও বেশি পোশাক ব্যবহার করে পূর্বে বর্তমানের অর্থ হলো ২৫০০ জন আহত হয়। যাদের ভোজনের বিনিয়োগ ছিল নারী।
নিদেশনিকা

এই নির্দেশনাটি দূর্যোগপ্রবণ অঞ্চলের ভবনাদি সম্পর্কিত পরামর্শ, নির্দেশনা এবং প্রয়োজনীয় তথ্য প্রদান করে। সচরাচর এবং ধন ধন ঘটে থাকা বিপর্যয়গুলোকে দক্ষভাবে মোকাবিলার উদ্দেশ্যে পরিকল্পনা, স্থান নির্বাচন, নকশা প্রণয়ন এবং গৃহনির্মাণ কৌশল সম্পর্কিত প্রয়োজনীয় নির্দেশনা এতে অন্তর্ভুক্ত রয়েছে। নিরাপত্তার নকশা এবং নির্মাণ সম্পর্কিত নীতিমালা বাংলাদেশ এবং নেপালের ভবন মালিক এবং নির্মাণকারীদের মধ্যে জন্য করে তোলা এর অভিজ্ঞতা লক্ষ্য। বাড়ির অধিবাসী এবং সম্পদের সুরক্ষা নিশ্চিতের মাধ্যমে বিপর্যয়ের সুরক্ষা স্বাক্ষরণ এর উদ্দেশ্যে। বর্তমান নির্দেশনায় নির্মাণ সম্পর্কিত ধারণাগুলো সঠিকভাবে অনুধাবন এবং ব্যবহার জন্য চিত্র সম্ভব আলোচনা রয়েছে। কেবলমাত্র বর্তমান মাধ্যমে উক্ত ধারণাগুলোর ব্যাখ্যা প্রদান যথেষ্ট দুর্বল।

ব্যবহারবিধি

গৃহনির্মাণের ক্ষেত্রে ভিড়ি, ছুটি, নেয়াল এবং ছাদের কোন ধরনের সময় নির্বাচন করা হবে তা নির্ধারণে ব্যবহারকারী বিচার ক্ষমতা অভিজ্ঞতা এবং পছন্দ গুরুত্বপূর্ণ বৃত্তিকা পালন করবে। বাড়ির নকশা প্রণয়নের ক্ষেত্রে এই নমনীয়তা ব্যবহারকারীদের অংশগ্রহণকে উৎসাহিত করবে।

এটি প্রশিক্ষণ নির্দেশনা রূপে ব্যবহৃত হবে পারে। প্রশিক্ষণ স্টেকহোস্টারদের সাথে আলোচনার মাধ্যমে বিভিন্ন বিবরণের মধ্য থেকে উপযুক্ত নকশা নির্বাচন সহায়তা করতে পারেন। নির্দেশার সারণীগুলো এই প্রক্রিয়াকে সহায়তা করার উদ্দেশ্যে প্রণীত।
নির্মাণ ধাপ

পরিকল্পনা

গৃহ নির্মাণের পূর্বে কোন স্থানের উপযুক্ততা এবং তার পরিবেশ সমন্ধে নিশ্চিত ধারণা গ্রহণ আবশ্যক।

ভূপ্রকৃতি

উচ্চতা, ঢাল, বন্ধুতা, জল নিহিতাশন, মাটির প্রকৃতি

অক্ষ-মূর্তিকার প্রকৃতি

নিহিতাশন নালী, জলপথ, জলাভূমি, তীর রেখা, জলপ্রবাহ

অভিগম্যতা

রাস্তার সাথে যোগাযোগ এবং ভূমির ছড়িবেষ্টন সমক্ষে বিখ্যাতলী, যোগাযোগব্যবস্থা এবং উদ্যান পথ

আকৃতি

গৃহনির্মাণের ক্ষেত্রে সাধারণ প্রতিসম আকৃতির গৃহ পীড়ন বলকে হ্রাস করে। এক্ষেত্রে বর্গাকৃতি এবং আয়তাকৃতি গৃহকে প্রথাগত দেয়া হয়।

ভিত্তি

বাড়ির ভিত্তি বা ফাউন্ডেশনের মূল কাজ হল বাড়ির কাঠামোর ভার, অনুযায়ী ভার এবং বাহ্যিক চাপকে সুরক্ষিতভাবে বস্তুর মাধ্যমে বাড়িকে নিরাপদ রাখা।

ভিত্তি তৈরির উদ্দেশ্য: হলে—

১। সহায়ী ভিত্তি উপর কোন কমনি ধরে রাখা।

২। পরিবর্তনের মধ্য দিয়ে যাওয়ার অত প্রাক্কাল শক্তি এবং দৃঢ়তা থাকা।

৩। নিশ্চিত থাকে এবং টেকসই হওয়া।
মূল অংশ

কাঠামোর ভার বহন, প্রতিকূল পরিবেশের হাত থেকে রক্ষা করা, বাতাস ও আলো চলাচলের উপযুক্ত করে এই অংশটি তৈরি করা প্যারামেটার।

প্রকার ১
কংক্রিটের কাঠামো এবং ইটের দেয়াল

প্রকার ২
ভার সহনশীল ইটের দেয়াল

প্রকার ৩
কাঠের কাঠামো এবং মাটির রূপ।

ছাদ

ছাদ নির্মাণের ক্ষেত্রে ২ ধরনের পদ্ধতি অনুসরণ করা যেতে পারে। এঁটেফেলানো শিট বা টাইলস দিয়ে তৈরী হেলানো বা চালু ছাদ। অথবা, রিনফোর্সড কংক্রিট প্ল্যাট দ্বারা তৈরি সমতল ছাদ।

প্রকার ১
রিনফোর্সড কংক্রিট

প্রকার ২
কাঠের কাঠামো এবং সি আই শিট/টাইলস
নির্মাণশৈলির বিকল্প

ক

খুঁটি
আর সি খুঁটি
কাঠ

খ

দেয়াল
ইট
kংক্রিট ব্লক
মাটির ব্লক
হালকা ওজনের বক্স
বাঁশ

গ

ছাদ
আর সি প্লাস্টিক
কাঠের ফ্রেম এবং
সি আই শিট/টাইলস
বৃষ্টির পানি নিষ্কাশনের জলাসাগর

ঘ
০১-পরিকল্পনা

বাতাসের চাপ বাড়ির উপর কতটা প্রভাব ফেলে তা নির্ধারণ করে বাড়ির গঠন, কতটুকু অংশের উপর বাতাস সরাসরি আঘাত করেছে, বাড়ি নির্মাণের গুণগত মান মৌলিক নকশাসমূহের মধ্যে সম্বন্ধ কতটা সুসংহত তার উপর।

উচ্চ দানান্ডলের থেকে অপেক্ষাকৃত নিচু দানান্ডলেকে ঘূর্ণিঝড় থেকে কিছুটা সুরক্ষা প্রদান করে।

ঘূর্ণিঝড় প্রবণ অঞ্চলে গুহ নির্মাণের জন্য স্থান বাছাইয়ের ক্ষেত্রে উচ্চ দানান্ডকে বাতাসের প্রতিবন্ধক রূপে ব্যবহার করা যেতে পারে।

ঘূর্ণিঝড়ের সৃষ্টি, স্থানীয় বায়ুর গ্র্যাপ্স, দমকা বাতাস এবং বায়ুহীন অনুবাদ অঞ্চল সৃষ্টি হওয়ার পেছনে অন্যতম কারণ হিসেবে উচ্চ দানান্ডকে ধরা যেতে পারে।

উচ্চ দানান্ডের আড়ালে থাকা স্থানগুলো বায়ু-সৃষ্টি বিপর্যয়গুলো থেকে কিছুটা সুরক্ষিত থাকে। খাড়া প্রান্ত এবং খাড়া উপত্যকা অঞ্চল যেসব সমুদ্রের দিকে উন্মুক্ত সেসব অঞ্চলগুলো এড়িয়ে যাওয়া উচিত।

বসতি নির্মাণের ক্ষেত্রে রৈখিক প্যাটার্ন পরিহারের কথা প্রয়োজন। কেননা উন্মুক্ত, সোজা ও সমান্তরাল পথে চলাচলের সময় বায়ুর গতি অত্যাধিক বৃদ্ধি পায় এবং “টানেল গ্র্যাপ্স” সৃষ্টি করে।
অত্যাধিক খাড়া ঢালের ছাদ বাতাসের চাপের সম্ভ্রী হয় তুলনামূলক বেশি। ফলে, ছাদ উঠে যাবার সম্ভ্রনা থাকে।

মজবুততাবে বাড়ির কাঠামো তৈরি হলেও, যদি তা তার ভিত্তির সাথে শক্তভাবে আটকানো না থাকে, তবে বাড়িটি সহজেই উল্টে যেতে পারে।

অত্যাধিক হেলানো ঢাল হলে, বাড়ির ছাদকে অধিক সাকাশন বা শোষণের সম্ভ্রিন হতে হয়। এতে করেও ছাদ উঠে যাবার সম্ভ্রনা তৈরি হয়।

মজবুততাবে বাড়ির কাঠামো তৈরি হলেও, যদি তা তার ভিত্তির সাথে শক্তভাবে আটকানো না থাকে, তবে বাড়িটি সহজেই উল্টে যেতে পারে।

বাড়ির ছাদের ঢাল ৩০° হলে সেটি সামান্য বাতাসের চাপের সম্ভ্রী হয়।

বাড়ি হতে কিছু দূরত্বে অবস্থিত গাছপালার আচ্ছাদন ঢালের সময় ঢাল হিসেবে কাজ করে বাড়িকে সরাসরি রাখে। বায়ুর প্রতিবেদন গাছপালার সর্বোচ্চ উভয়তার সমান দূরত্বে বাড়িটি অবস্থিত হবে। এছাড়াও, উঁচু ভিত্তির উপর তৈরি করা বাড়ি কন্ধার সময় বাড়িটিকে বন্যা যুক্ত রাখবে।
গৃহ নির্মাণের জন্য ল্যান্ড নির্বাচনের ক্ষেত্রে ভূমির ছায়াপত্র এবং একই সাথে ঘড়া বাসার এবং বন্যার হাত থেকে গৃহকে নিরাপদ রাখার মাত্র বিষয়গুলো বিবেচনায় আনতে হয়। অন্য তেলোন জটিল জ্যামিতিক আকৃতি অপেক্ষা সাধারণ আয়তনকৃতির ভবন ভূমিকম্পের সময় অপেক্ষা নিয়ন্ত্রণ। ভ-এলাওপুরের দরজা সৃষ্টি করা লম্বা ও সরু আয়তকৃতির বক্রের উপর সুন্ডারভাবে লক্ষ্যীয়।

এমন ভবনের দরজায় তার প্রাঙ্গণ ৩ নগ্রা মূলে সীমাবদ্ধ থাকা বাণী নয়। তবে, দরজা এর চেয়ে বাড়াতে হলে দুটো আলাদা বক্র তৈরি করা উচিত।

প্রতিসাম্য এবং ধারাবাহিকতা অর্জনের জন্য বড় দলালানকে কতগুলো বক্র বিভক্ত করা প্রয়োজন।

জালালান্দুর এবং উপকূলীয় সমুদ্রের চেয়ে থেকে জানবসাতি রক্ষার্থে বাড়ি নির্মাণ করতে হবে। সমুদ্রান্তরীণ পান্ডের শর্করা কমানোর জন্য পাথর ব্যবহার করতে হবে। অপর পান্ডের গভীর মূলবিশিষ্ট বৃক্ষোপসাগর করতে হবে তাতে মাটিকে একটি ধরে রাখা যায় এবং কেম হয়।

নদীর মোহনার মাধ্যমে জুরিকুড়ার প্রবাস চলাচলে বন্যার সৃষ্টি করতে পারে। এজন্য, বন্যা-নিরাপদ, জরুরি উদ্যানন পথ এবং আশ্রয় অঞ্চল তৈরি করা বিশেষ প্রয়োজন।

নদীর মোহনার মাধ্যমে জুরিকুড়ার প্রবাস চলাচলে বন্যার সৃষ্টি করতে পারে।
ধারাবাহিক

মাটি ও সিমেন্টের মিশ্রণের মাধ্যমে মাটির ভিত্তি তৈরি করা যেতে পারে। সিমেন্টকে নূনতম ৩ সেঞ্চুরির পানি দিয়ে কিওটিং করতে হবে।
বিকল্পঃ ছিটিশীল এবং ডুঁব মাটির ভিত্তি ব্যবহার করা।

কঠিনের টপিং (৪ সে.মি.)
সিমেন্টের লিন (১০ সে.মি.)
সমতল ইটের সোলিং
বালু
কমপ্যাকশন
ফুটিং

কলাম ফুটিং

- কলামের নিচে স্তরীভূত ফুটিং ব্যবহার করা
- মাটির উপরে ভার সম্ভবত বন্ধ করা
- বর্ষ, আয়ত অথবা গোলকৃতি
- মাটির ভার বহন মতার উপর ভিত্তি করে ইট, পাথর
  রিনফোস্ট যোগেন ফুটিং ব্যবহার করা যেতে পারে।

দেয়ালের ফুটিং এবং আর সি ফুটিং

- কয়েক সেন্টি ইঞ্চির সারি, উপরের ফুটিংয়ে নিচের জোরের পুরুত্ব দ্বিগুণ হবে।
- চওড়া ভিত্রের জন্য ৫ সেমি অফসেট ব্যবহার, ইটের
  দেয়ালগুলো এক ইটের সমান চওড়া হবে। কিন্তু, বিশেষ ক্ষেত্রে
  নিচের দিকের সাতগুলো দুই ইটের সমান চওড়া হতে পারে।
- লিন বা পাতলা কঠিনের চেয়ে সর্বনিম্ন ১৫ সেমি হয়। প্রতি
  পাশের প্রজেকশন ১০-২৫ সেমি, নেস ওয়ালের বাইরে বেড়ের
  গতিরতা প্রজেকশন এর চেয়ে কম হওয়া যাবে না।
- ওয়াল ফুটিং হর করা ক্ষেত্রে কঠিনের বেড সমতল পৃষ্ঠ
  নিপীড়িত করে। খাঁচাওয়া এবং ব্রিজ তৈরিতে নরম মাটিতে সৃষ্ট অসমান্তরালের প্রতিকার করে।
- যখন লেজের অনেক বেশি থাকে এবং মাটির ভার বহন
  ক্ষমতা কম থাকে তখন আর সি ফুটিং ব্যবহার করা যায়।
  অন্যান্য বিশ্লেষণের কাঠামো তৈরীর আবশ্যকতা দেখা দেয় যা
  অপরটিনিগেটিভে বোঝাই যায়।
- ৭-৮ সেমি পাতলা কঠিনের বেড ব্যবহার করতে হবে আর সিও
  ফুটিংয়ের নিচে।
ফুটিংয়ের প্রকারভেদ

কাঠ/বাঁশের খুঁটি

কংক্রিট/ইটের খুঁটি
আর সি কংক্রিট খুঁটি

১. কংক্রিটের মিশ্রণের অনুপাত সাধারণত সিমেন্ট, বালু এবং খোয়ার জন্য ১:২:৩ অথবা ১২:৪ রাখা হয়।

২. রিনফোর্সমেন্ট হিসেবে নিম্নক্ষুর থেকোনটি ব্যবহার করা যেতে পারে -
   (ক) হালকা ও মাঝারি শক্তির প্রসারণযোগ্য স্টিলের বার
   (খ) অধিক শক্তিশালী পরিবর্তিত স্টিল বার

৩. সকল রিনফোর্সমেন্টকে মরিচা এবং রং, তেল, কর্ম অথবা অন্য থেকেন পদার্থ যা কংক্রিটের বক্ষফেনকে নষ্ট করে দেয় বা হারালে তা থেকে মুক্ত রাখতে হবে। চার স্টেলবিশিষ্ট ২৫ মিমি ব্যাসের রি-বার ব্যবহার করতে হবে যা ৬ মিমি ব্যাসের স্টিলের সাথে যুক্ত থাকবে। ৪-১০ ইঞ্চি ফাঁকা রাখতে হবে।

৪. বর্গাকৃতির কলামের মাপ নূনতম ২০:২০ সেমি হতে হবে এবং একটি কলাম হতে অপর কলামের দুরত্ব ৩ মিটারের বেশি রাখা যাবে না।

৫. দেয়ালকে ধরে রাখার জন্য এবং ছাদের ভিত্তি হিসেবে কংক্রিটের ক্রম ব্যবহার করতে হবে। অথবা, ছাদের প্রাথমিক একই কাজে ব্যবহার করা যায়।

৫. চারপাশের কংক্রিট রেডার থেকে রেইন করে উপরে উঠবে, আচারে গিয়ে মিলিত হবে।

বিস্তারিত

প্যান

রিনফোর্সমেন্ট

স্টেল স্টিরাপ

১/৪" অথবা ৩/৮" স্টিল বার

ঝুঁটিতের ঝুঁটি

এক্সনোমেট্রিক
০৪- দেয়াল

ভার বহনকারী দেয়াল

হালকা স্টিল বার, হ্রদ লোহা, সম্প্রসারিত জল অথবা বারের মাধ্যমে মজবুত গাঠনির কাজ করা সহজ। যে কোন ধরনের চাপ যা উদ্দেশ্য, সংকোচন বা বিভিন্ন সূচির করে তা প্রতিহত করতে এই মজবুত গাঠনি সাহায্য করে।

আড়াআড়িভাবে প্রবাহিত শক্তিকেও প্রতিহত করার সামর্থ্য রাখে:

- ভারালোড়ন এবং ঘূর্ণিঝড় প্রবণ অঞ্চল
- কোন মিলনের বা ফাঁকা জায়গা ব্যতীত লম্বা দেয়ালগুলোর জন্য।
- রিনফোর্সড সেকশন তৈরি করার ক্ষেত্রে ফাঁকা দেয়ালের জন্য <১.২ মিটার ব্যবধান এবং নির্দেশ দেয়ালের জন্য ২.০ মিটার ব্যবধান রাখতে হবে।
- রিনফোর্সমেন্টের চারিদিকে ১৫.২৫ সেমি আবরণ প্রয়োজন যাতে যকৃত প্রতিহত করা যায়।
- রিনফোর্সম্ব ইটের কলাম এবং মেঝের শ্যাব ও প্রয়োজন।
- দেয়ালের জন্য কংক্রিটের ধারাবাহিক যুক্তি এবং প্রত্যেক কোণায়, দুটি দেয়ালের মিলন না-র, দরজায় প্রত্যেক কোণায়, এবং ফাঁকা জায়গায় এবং মাকামাঝি জায়গায় <১.২ মিটার ব্যবধানে রিনফোর্সেড বার ব্যবহার করতে হবে।
উপরিভ্রে
কঠিনার
ফ্রেম

কঠিনার চৌকাঠ

ভার বহনকারী দেয়াল

প্রত্যেক কোণা এবং
উন্মুক্ত জায়গার
চারপাশে
রিনফোর্সমেন্ট

কঠিনার ব্যান/টাই বিম

কঠিনারের মেঝের স্যাব
Majurbat Gauthini

The design of the structure involves two layers of materials. The second layer is made of bricks and the first layer is made of concrete. The two layers are connected by a reinforcement metal frame. This structure is designed to withstand earthquakes and other natural disasters.
কাঠের ফ্রেম

স্টাডগুলিকের জন্য কাঠের স্টাড এবং সিলস, টপ পেট এবং ওয়াল পেটের সাথে যুক্ত করা হয়। এপর্কুলার প্রেসিং ব্যবহার করা হয় যাতে ভিন্ন পরিস্থিতিতে ওয়ালস এবং সিলসের পাশের কাঠের কন্ট্রোল শেককে শতকালে ধরে রাখা যায়। দেয়ালের আচ্ছাদনের জন্য বীথ নলাহাগড়া অথবা কাঠের বোর্ড জাতীয় বস্তু ব্যবহৃত হয়।

১. সিল সাধারণত ৪০ x ৯০ মিমি, ৩০ x ৯০ মিমি অথবা এর চেয়ে বড় মাপের হয়। সিলগুলো ফাউন্ডেশনের সাথে অ্যাক্সেপ্টের মাধ্যমে যুক্ত থাকে যার সর্বনিম্ন ব্যাস ১২ মিমি এবং দৈর্ঘ্য ৩৫০ মিমি। সিলের সংখ্যার দুপাশেই বোল্ট লাগানো হয় এবং এদের মধ্যবর্তী দূরত্ব সর্বোচ্চ ২ মিটার।

২. স্টাডের সর্বনিম্ন মাপ ৪০ x ৯০ মিমি, ৪০ x ৯০ মিমি স্টাড ব্যবহার করা হলে তাদের মধ্যবর্তী দূরত্ব ০.৫ মিটার রাখা উচিত। ৯০ ৯০ মিমি এর ক্ষেত্রে এই দূরত্ব দ্বিগুণ হবে। কিছু চেতার এবং বার্ডের লাইলিং পুরু হওয়া প্রয়োজন।

৩. কোন তলার উচ্চতা ২.৭ মিটারের অধিক হওয়া উচিত না। সোলেল বাড়ির জন্য স্টাডগুলোকে ০.৫ মিটার পরপর বসাতে হবে।

৪. স্টাডের উপরের অংশ টপ পেটের সাথে যুক্ত থাকে এবং টপ পেটের মাপ স্টাডের তুলনায় কম হওয়া যাবে না।

সিলস, স্টাড এবং টপ পেটের ক্ষেত্রে তৈরি ওয়াল ফ্রেমিং এর কোন কোন প্রেসিং বা পেশিং বোর্ড দিতে হবে যাতে ফ্রেমিং শিয়ার অথবা প্রেসিং ওয়াল হিসেবে কাজ করে। যদি কোন পেশিং বোর্ড না করা হয় তাহলে, তবে সর্বসময় স্টাডকে পাশরিত স্টাডগুলোর সাথে অনুভূতিক ব্যবহারের মাধ্যমে প্রতি ১.৫ মিটার পরপর লাগাতে হবে।
উপরিভাগ কাটার চেমের দের
মাটির ভরাট

দরজার চোকাঠ

আড়াআড়ি প্রাফিং

আড়াআড়ি প্রাফিং

নিচের দের
(২০ x ৪০)

কোণার কাটার দুটি
(৯০ x ৯০)

কঠিনের ভিত্তি
৫ ছাদ : প্রধান নীতিমালা

এরোডাইনামিক ছাদের গঠন

১. ছাদের ডাল ৩০°-৪০° এর মধ্যে সীমাবদ্ধ রাখতে হবে যাতে বাতাসের প্রভাবে শোষণ এবং ছাদ উড়ে যাওয়া উজ্জ্বলকেই মোকাকিলা করা।

২. দোচালা ছাদের চেয়ে চোচালা ছাদকে প্রাথমিক দিতে হবে। চোচালা ছাদের ক্ষেত্রে তা কাঠামোর সাথে মজবুতভাবে আঁকড়াতে হবে। লিন-টু না ঠেস দেয়া বাড়ি সম্পূর্ণ পরিহার করে চলতে হবে।

৩. বুলন্ড <২'-৬" , ছাদে টেলিপয়েড ব্যবস্থা থাকতে হবে এবং প্রাচীর থাকবে।

৪. আর সি ছাদ সরবরাহ সুরা প্রদান করে। পৃষ্ঠ পরিমাণে উল্লেখ ক্রেসের জন্য এর ব্যবহার।

কাঠামোর সাথে যুক্ত ছাদ

১. মুদ্রাশিকৃত ছানে রাফটার ব্যবহার করতে হবে।

২. ছাদ এবং উল্ল কাঠামোর মধ্যে ভাল যোগাযোগ রাখতে হবে। উভয় পাশেই সাধারণ নেইলের পরিবর্তে ধাতব স্ট্রিপ এবং ওয়াবারসহ বোন্ট ব্যবহার করতে হবে।

৩. বুলন্ড <২'-৬" , ছাদে টেলিপয়েড ব্যবস্থা থাকতে হবে এবং প্রাচীর থাকবে।

সুগঠিত ছাদের আচ্ছাদন

১. প্রত্যেক ভাঙাভাঙা সি আই শিট লাগাতে হবে। ফজলাচাই টাইলস বসাতে হবে।

২. জে-হুক বোন্ট এবং ফ্রেড টাইটেড করিয়ে নেইল ব্যবহার করতে হবে।

কাঠের ক্রেম

১. নিয়মিত পরীক্ষা করতে হবে, বিশেষকে উপরের অংশ এবং কোণায়।

২. দূর্বল হয় যাওয়া অংশের পরিবর্তন করতে হবে এবং চিনা হয়ে যাওয়া অংশের সেরামিক করতে হবে।

৩. বাতাসের বার্তায় যাতে ছাদ উড়ে না যায় প্রেরণ সি,আই শিটকে শক্তিকে কাঠামোর সাথে আঁকড়াতে হবে।

ছাদের আকৃতি

চোচালা

দোচালা

একালা
কাঠের ফ্রেমের কাঠামো

ঢালের উপর উর্ধ্বগম্য বক কমানোর জন্য এবং যথাযথভাবে বৃত্তির পানি অপসারণের উদ্দেশ্যে পর্যাপ্ত ঢালের কেবলে ঢাল ব্যবহার করা উচিত।

১. কুপ্লে অংশ সর্বোচ্চ ৬০০ মিলিমিটার হতে পারে।

২. ঢালের কাঠামো তৈরিতে বেসব কাঠ বাহার করা হবে, তা অবশ্যই প্রিজারমেটেড সম্র ও মজারুত কাঠ হতে হবে।

৩. ঢাল তৈরির সময় অংশ একে অপরের সাথে খালোভাবে যুক্ত হতে হবে। মিনি- পালন, বর্ণণ রাক্ষনর সাথে, বর্ণণ দেয়ালের সাথে, দেয়ালের পাত বৃত্ত সাথে।

৪. ঢালের প্রতিটি ভিত্তি পালনের সাথে ছুক বোল্ট বা ট্যাঙ্টল নেইলস দিয়ে আউটকাল থাকবে।

প্রতি ১০ সেমি পরপর
বর্ণণ/রাক্ষন

প্রতি ১০ সেমি পরপর
পালন

ধারাবাহিক রানার

অতিরিক্ত পালন প্রতি ৪৫ সেমি পরপর
দোচালা ছাদ

ধারাবাহিক রানার

পালিন

রাক্ষার

অতিরিক্ত পালিন

সরবোচ্চ কূপন (৪০
গোল)

দুই বীটির মধ্যে সরবোচ্চ
দূরত্ব (৩ মি)

মেশের কংক্রিট শাব
ঠৌচালা ছাদ

পাল্লিন

রাফটার

অতিরিক্ত পাল্লিন

দুই ঢুটির মধ্যে সর্বোচ্চ দূরত্ব (৩ মি)

মেকের কংক্রিট শ্রাব
ধাতব কাঠামো

- সি আই পিট
- কিং বুট
- এমএস কোণ
- রাফটার
- টাই বিম
- পানি নিভাপানের নালা
- এমএস সমতল
- প্যাব বার
मध्यमार्ग

निर्माण सम्बन्धी हातेपुस्तिका

नेपाल र बाङ्लादेशको उदाहरण

एशिया-पॅसिफिक नेटवर्क फर रोज़ाल चेन्ज़ रिसर्च (एपीएन) को अनुदान तथा कोलोराडो स्टेट रिजनल रिसर्च प्रोग्राम (सीआरआरपी) को सहयोगमा
मध्य एशिया विपद उत्थानशील भवन निर्माण संस्थानका अवसर र चुनौतीको बुझाई
नेपाल र बांग्लादेशको उदाहरण

श्रीमान अफ आर्किटेक्चर एन्झ बिल्ट इम्यारोमेंट, युनिमर्सिटी अफ न्युक्यासल, अस्ट्रेलिया
दा. इस्माइल अहमद
प्रोफेसर धार्मिक विभागा गजेन्द्र
प्रोफेसर ग्राहम ब्रिग्स
दा. किम मैन्ड
दा. जेसन बीन मेंडिक
जरिया किसा (अनुसंधान सहयोगी)

भूमी र वातावरण विभाग
युनिमर्सिटी अफ व्हाका, बांग्लादेश
प्रोफेसर हम्नुम कबिर
आर्किटेक्चर विभाग
बाक विश्वविद्यालय, बांग्लादेश
दा. मोहम्मद फालक

उद्योगीय अर्थव्यवस्था संस्थान, विभवन विश्वविद्यालय, नेपाल
प्र. दा. हरिदेवन स्पेन
सह-प्र. नेपेन्द्रज सिद्धोल
उप-प्र. इतु प्रवाह साकिक

हालिनिर्दिष्टा डिजाइन, शब्द र विज़्नु
जरिया किसा
अनुसंधान सहयोगी, युनिमर्सिटी अफ न्युक्यासल, अस्ट्रेलिया
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প্রাক্কথন

য়ে হলোপউলিতকারো প্রকাশন এশিয়া প্যাসিফিক নেটওয়ার্ক ফার গ্লোবাল চেন্জ রিসার্চকো সহযোগিতা “দক্ষতা এশিয়ায়া বিপদ উদাহরণশীল (disaster resilience) নিম্নাংশ সহায়তা অবসর র নূনীতিতে অন্য উমে বাড়া দৈবালী র নেপালুক্সের অবস্থা” নামক কোনালেরেটিভ রিজনাল রিসার্চ প্রোগ্রাম অনুষ্ঠান প্রতিযোগি হেফে হেফে। বাড়ালীবাদের ব্যবসায়িত র ব্যবসায়িত অর্থ নেপালুক্সের নিবিন্দন বিশ্ববিদ্যালয়সমূহের সহায়তার রহেতে কোন পরিযোজনার নেতৃত্ব অস্ত্রেশিতঃ পুনরায় নির্দেশরো পয়ে।

বিষয়বস্তুর নির্দিষ্ট বন্ধমান ছি। প্রয়ঃ গঠন্তে বিপদকোর গুম্বোর অশাকাল্পের পূর্বাশা দৈবালী সমাধানঃ বেচদী পরে গেরো ছি। বিপদ মূল্য বিকাশী মূল্যের অবস্থিত বস্তুপ্রতি বৈশিক চারিত জাতিতালী অসাভাবিক-ভাবায় হামি গেরে ছি। অনীপচারিক কিশোরের মানানো প্রায় ঘটে সংক্টায়ন্ত্রনাং অভ্যন্তরীণ (vulnerable) পাঁচের ৪। পর নিম্নাংশ র আরোপূর্ব সাধারণ নিম্নাংশরা যাত্রায়ন জাতিতালী বেচদী সুরক্ষিত র উদাহরণশীল বনামে সুসংহত সামান্য গুরুত্বের জোড়ানাং ঘটাউটি। তত্ত্ব দক্ষতা বিকাশী মূল্যের অর্থনীতি সাধারণতার দিকিতে দেশান্তরীণ বন্ধন নিম্নাংশ সহায়তার অনুকরণ হারি বাড়ালী হননি। শোকাকৃত অর্থনীতি কর্ম ভূসদুঃখে, নিম্নাংশরা কার্যকর নগর্ন অবস্থায়প্রেরণ ফিতাল হনা দেশান্তরীণ সাধারণতাচারিক অনুচ্ছেদ কার্যকরী বন্ধন নিম্নাংশ সংখ্যা গুরুত্ব অর্থ করিত গেরে ছি।

ত্রৈড়ের সুবিন্দু বন্ধন নিম্নাংশ সহায়তা সাধারণত লাখু হনে পরিকল্পনা তদার গেরনে নিবন্ধন উপত্য খেজু সাধারণত হন। তত্ত্ব বন্ধন নিম্নাংশ সহায়তার অনীপবারিক কার্যক্রম মাত্র সীমিত নগরী অনীপবারিক কার্যক্রমের সমত বন্ধ-স্ফূর্ত লাখু গেরনে উদকরিত গুরুত্বপূর্ণ ছি।

পরিযোজনা

যাহে বিশ্বজন্ম দক্ষতা এশিয়ায়া বিপদ উদাহরণশীলতাকার লাগি সাধারণ সদন্তলাহীন সমৈক্য কার্যক্রম বিকাশী মূল্যের দেশান্তরীণ সাধারণতার অনুচ্ছেদ তথা আধিক পরিনতিমান উপার্জন প্রদত্ত বন্ধন হননি। যাহে হলোপউলিত তদার গেরে ছি। যামে এই বিকাশী মূল্যের দূরীত্ব দেখাও দৈবালী র নেপালুক্সের অন্তর্ব্যাপরীণ অবস্থা হেফে জাগ্রত অর্থনীতি অপনাতন সমাধান হন। যামে এই ব্যক্তি গেরিকায় সাধারণতার উদাহরণ রাস্তা প্রোমুণ্ড ব্যাখ্যান গেরে সাধারণ নিম্নাংশ অর্থনীতি হন।

যাহে বিকাশী মূল্যের দূরীত্ব দেখাও দৈবালী র নেপালুক্সের অন্তর্ব্যাপরীণ অবস্থা হেফে জাগ্রত অর্থনীতি অপনাতন সমাধান হন। যামে এই ব্যক্তি গেরিকায় সাধারণতার উদাহরণ রাস্তা প্রোমুণ্ড ব্যাখ্যান গেরে সাধারণ নিম্নাংশ অর্থনীতি হন।
नेपाल

नेपाल मूलतः दोंडाकोडाघर भरिएको र जटिल भौगोलिक बनावट भएको देश हो जहाँ विभिन्न खालको घावापनी पाइन्छ। यस बाहेक, यसका भूगर्भमा रहेका चट्टानका फटहरू चलायमान छन्। नेपाल भूक्षण, बाढी, आंधीवेहरी, पहिरो लगायतल्लो धेरै खालका प्रक्रियाका कारण जोखिममा रहेका छ र अनेक विपदको सामना गनुन्तरको छ। अघ्यात्त शहरीकरण जसला मानवीय गतिविधिर र अपर्याप्त भवन पुर्याधारले विपदको अखार अखार बढने गरेको छ। सन् २०१५ मा नेपालमा गएको भूक्षणले धेरै घर भकायो र ती घर महिलाएँ किस्मा धेरै मानिसले ज्ञान गयो।

बाष्लादेश

बाष्लादेश प्राकृतिक प्रक्रिया  र जलवायु परिवर्तनको सवैभव्य बढी संकटसमन्तर रहेका विश्वका देशगतमा पद्भो। यहाँका भ्रमण प्रक्रियाको बढी र तुफान हुन। बाष्लादेशको आधारभूत प्रक्रियाको बढी र तुफान भए तापस से तुलना वितरण भएका अघ्यात्त शहरी क्षेत्रका भूक्षण र आगजनीजन्य प्रक्रियाको पनि उत्कृष्ट जोखिम छ। भवन निर्माण समस्या नियम र सहक्षेप उल्लम्बन गर्न तथा पालन नगर चलने गर्दा प्राकृतिक प्रक्रिया विना पनि विपदमा परि मानिसको ज्ञान जाने गरेको छ। बाष्लादेशमा सन् २०१३ मा रास्ता प्रान्त अग्रियाएको कारणमा भारी ९०० महिलाले १००० भन्दा बढी — भूक्षण: ग्रामीण कामदारको — भूक्षण भएको र २५०० जना घाइते भएको घटनाले यही कुरालो पृथ्वी गर्न।
हालेपुसितिका

यस हालेपुसितिकाले विद्ययुक्त क्षेत्रमा पटक पटक हुने प्रकोपबाट उत्खानशीलताका लागि भवन निर्माण योजना, खालो चयन र बनावटको संचारा एवं निर्माणसंग सम्बन्धित मुख्य मुख्य विषयमा सल्लाह, सुभाष र जर्जर जानकारी दिइएको छ।

यसका लक्षित वर्ग भनेका नेपाल तथा बाङ्लादेशका स्थानीय ढेरेदर र घरशीली हुन र यस हालेपुसितिकाले उनीहरूलाई तैलकित गरी भवन निर्माण गर्न जनवनको सुरक्षा गरेतर प्रौद्योगिकी गर्न लक्ष्य रिएको छ। निर्माण सम्बन्धी धेरै अवधारणाको वर्णन गर्न सफल छैन। त्यसैले यी कुरा उदाहरण र घर कसैली सामग्री सङ्केत भनाउन भने कुराको व्याख्या गर्न राम्रा अभ्यासहरूका उदाहरणका धित्र दिइएका छैन।

हालेपुसितिका प्रयोग गर्ने तरिका

भवन निर्माणको योजना भन्दा बनाउदा जग, खच्छ, मिल्चा र छाना कसैं बनाउदा उपयुक्त हुन भने विषयमा उनीहरूको अनुभव, ठहर र छनोटको महत्त्वपूर्ण भूमिका खेलछ। यस हालेपुसितिकामा भएका धेरै विकल्पहरूले घरधारीलाई छोटोटमा लब्धता प्रदान गर्मुका साथै उनीहरूको सहभागिताको युनिशेयरता गरेको छ। यसो गर्न धरको डिजाइन बनाउदा घरधारीलाई सहभागी गराउन सकिन्छ।

यस हालेपुसितिकालाई तालिम सामयिकी रूपमा पनि उपयोग गर्न सकिन्छ। धरको मुख्य भाग निर्माण सम्बन्धी यही दिइएका विष्य विकल्पका मूल्यांकनका आधारमा घरधारी र ठेकेदारहरूको बीचमा छलफल चलाएर प्रशिक्षकले धरको जुन डिजाइन उपयुक्त हुन भनेबाटेको निर्णय गर्न लगाउन सक्छन्।

यस प्रक्रियालाई सरल भनाउन तालिका पनि दिइएका छैन।
भवन निर्माणका चरण

योजना तथ्यमा

घर बनाउनुमा पहिले घर बनाउन चाहेको ठाँचे र व्याख्याैंको वातावरण उपयुक्त ४ कि छैन भनी हेँनुपाई ।

भौगोलिक बनावट
उचाई, गिराउने, खल्का, बल तथा वर्षाको पानीको निकास, जमिनको अवस्था

जमिनमूल्यको अवस्था
बल तथा वर्षाको पानी जाने बाटो, पानीको निकास, उद्यम, नदी/समुद्रको किनार, नहर किनार, खोलाखोली

पहिरुहे मार्ग
घर बनाउने ढाँचैसम्म पुनर्निर्माण र जमिनको सिध्दांतस्रोत सम्बन्धित विषय, रस्ता, उद्यान, लागि बाटो

आकार
साधारण खालको समाकार जमिन छानुहोस् जसले गर्दा बलको तनावबाट हुने असर कम हुन्छ ।

वर्गाकार र आयातकार (बार कुना मिलेरको) जमिन उपयुक्त हुन्छ ।

जग

भवनमा आइपने भार जस्ती भवन तथा जग, मानिस तथा सरसामान लगाउन अन्य बाह्य तत्त्व दिने भारसमेतलाई जमिनमा समान वितरण गरी भवनलाई पुरुषित बनाउनु भने जगको पुख्त काम हो ।

जग निर्माणको उदेश्य निम्न हुन ।
1. तौँकिएको सीमामन्दा बढी जग भासिं नपदिन
2. घरको भार वहन गर्न सक्ने क्षमता बढाउन र माटोको स्वरूप परिवर्तन हुन नपदिन
3. लोक र टिकाउन बनाउन
मुख्य अंग

घरको मुख्य अंग भवनको भर वहन गर्नका लागि उपयुक्त हुनुपर्छ। यसले जुनपुरकै बाह्य अवस्थालाई प्रतिस्थापन गर्नु पर्छ र त्यों दोनो चबैने हावा र प्रकाश छिन्न दिनुपर्छ।

पहिलो प्रकारको घर

बलन र फलाम (आरसीसी) राखेको खम्भा र दलिनले भर वहन गर्न (पिलर भएको घर) र तुंगा तथा ईंटाको मिला भएको।

दूस्रो प्रकारको घर

मिलाए नै भर वहन गर्न (लोड वियरिंग सिस्टमको घर)।

तेस्रो प्रकारको घर

काठको खम्भा र दलिनले बनेको माटो र अन्य सामग्री प्रयोग भएको मिला।

छानो

भिरालो पाखो पारे त्यसमा जस्तापाता अथवा टायललगाए भनाउन सकिन्छ। ज्याम्बी प्रयोग गरे बलन भएको समात छानो पनि भनाउन सकिन्छ।

पहिलो प्रकारको छानो

फलाम ज्याम्बी राखेको गरेको छानो।

दूसरो प्रकारको छानो

काठको डोंडामाटा (दृस्त) बनाइ त्यसमाधि जस्ता तथा अन्य पाता/टायल आदिले छानो।
निर्माणका विभिन्न विकल्प

क
जग
अन्वरत जोडिएको जग

ख
खम्बा
आरसी.सी. पिलाई वा काठका खम्बा

ग
भित्ता
हङ्गाड/डुगा
कक्किट क्लक
माटाको ब्लक
हल्का सामग्रीहरू
(काठ, बौँस, पुस्कोभित्ता)

घ
छानो
आरसी.सी. ढलान
काठको डिम्नाडाटमान्धी जस्ता तथा
अन्य पाता/टायल
बरातको पानी बने हुँद
09 योजना तर्जुमा

गरते हवाओ कति दूले धक्का थे न सक्ष भने कुरा धरको स्वरूप, धर हवाको बहावको कुन दिशामा अवस्थित छ भने कुरा, निमाण सामानको गुणस्तर र आधारभूत डिजाइनको संरचनामा बनावटमा भर पर्छ।

चक्रवात आएको बेलामा अग्ला घरले होचा घरलाई केहि हदसमा सुरक्षा प्रदान गर्नु ।

चक्रवातको विस्तृत भएका तारुणा निमाण स्थलको योजना बनाउँदा दीवारका अग्ला भवन बनाईए तिनलाई धैर्य रोके सान्तानका सुरक्षा उपयोग गर्नस्तर विचार गर्नु पर्छ।

अर्कोतिर, अग्ला भवनले गर्दा उंची तिनर्जन पनि हुन सक्ष, दर्शनीय हवा उटो दिशामा बहन पनि सक्ष, धैर्य तिनर्जन हुन सक्ष हवाले कुन पनि वस्तुलाई आँफुतिर ताने अवस्था बन सक्ष।

हवा आउने दिशामा बनेका अग्ला धरको पछाडि आँध्रा बनाएका धरा हवाको प्रकार कम हुने। भिलाई पाखाको किनारामा र समुदाय वर्कका भित्रला उपस्थिकमा घर बनाउँदैन।

लम्बाई अति घेरे भएको घर बनाउँदैन किनमुगर्ने तसो गर्दा लोको, खुला र समानस्तर बाटो भएर हुरी बहन र हुरीको गति बढौर 'हवाको खुर्नी' बनी असर पर्ने हुनाई परिशोलाई लामो हुनेगरी कुन पनि संरचना बनाउँदैन।
धेरै मिरालो खाना भएको घरमा हावाको धक्का धेरै पनि सक्छ जसले गर्दा छानामित्र हावा पसौर रखसले खानो उडाउन सक्छ ।

कम मिरालो खाना भएको घरको छानालाई बडी हावाको खिचाइले उडाउन सक्छ ।

समान्यतया, 30° कोणको मिरालो छानामा हावाको धक्का सबैभन्दा कम पछि ।

भवन बनाउँदा जग्संग राम्री कसिएको छैन भने भवनका अन्य भागहरू जलियुक्त राम्रोसंग बनाइए पनि ल्यस्ता भवन पुनिन सक्छन् ।

जोनी दह्नसंग नक्सीकन बनाइएका घरका अंगहरू बागिन सक्छन् ।

हावाको बहाव छैन हावा आउने दिशालाई रोपिएका ब्राउला रूखको उचाई बराबरको दूरी घरबाट हुनेगाँरी रूख रोने गरेको हुरीबतास्वात घर सुरक्षित हुन्छ ।
ভবন নির্মাণ ক্ষেত্রে চারটি জমিতে গিয়ে চারটি ভিত্তি নির্মাণ করা হয়। এইভাবে, বাড়ি অথবা অন্য কোন অধিকারী দক্ষতার প্রয়োজনে তাঁর কাছে কম্পিউটার বাধ্যতামূলক পরিবর্তন করা যেতে পারে।

চীনামাত্রার এই সমস্ত চীনামাত্রার ক্ষেত্রে প্রতিবেদন প্রকৃতপক্ষে সম্ভব। লাভ করা যেতে পারে গ্রামের জন্য সমস্ত সম্পদ সম্পত্তির একটি পরিসংখ্যান অন্তর্ভুক্ত করা।

েখানে বাঁধাই এবং বাঁধাই অন্যান্য পদ্ধতি বর্তমান গুরুত্বপূর্ণ হলে তাঁর বিশ্বাস প্রকৃতপক্ষে সম্ভব।

এই রূপে এর পরিসংখ্যান প্রক্রিয়াটি জমিতে গিয়ে পরিবর্তন করা যেতে পারে।

হয়ে ভবন (খণ্ড) এর বীমান নিয়ন্ত্রণ বা সম্পাদন কার্য রাখাকে লাগি তুলে ভবনভিত্তি বিক্রয় করা হয়।
अनवरत जग

माटोको जग उठाउनका लागि माटो र सिमेंटको मिश्रणलाई 3:1 भागमा मिसाउनुपर्छ। यसै मिसाएको मिश्रणलाई तीन हजारसम्म पानी पटाएर चिनो राख्नुपर्छ।

वैकल्पिक उपाय : शितर माटोको अर्लो जग।
ख

हातीपाइले जग (फुटिड़)

खम्भाको हातीपाइले जग

• पिलको जग एकापल्ला नजोडीको बेलापर्दा हातीपाइले जग राखे।
• यसले पिलबाट आउने सम्पूर्ण केंद्रीकृत भारलाई जमिनमा समान रूपमा सबैभित्र बरबारी बौँदौँ。
• सामान्यतया, वर्गीकरण, आयातकीकरण अथवा गोलाकार फुटिड बनाउन सकिन्छ।
• जमिनको भार वहन वक्षमा र भवनले वहन गन्तव्यन् भार (वजन) हेरेर इंटा, ढुंगा अथवा आर्सीको फुटिड पनि बनाउन सकिन्छ।

पर्वतलोक पुटिड र डेंड्री सहितको ढलानको जग

• इंटाका धेरै तह जसला सबैभन्दा ठलको तह माथिको गारोको चौडाईमध्येत दोबार बुनोपर्न।
• फरकलो आचारको लागि ५ सेमिको आफ्नो टेस्ट (आट), हरेक पुटिडको तह कम्शीमा आउदा इंटाको मोटाइ बरबार बुनोपर्न। कहींले काली सबैभन्दा ठलको तह दुईभित्र इंटा बरबार मोटो पनि बुन सक्छ।
• कॉन्कर्टको पालि तह, कम्शीमा १५ सेमि. मोटाई, हरेक साइड (पाटा) मा १०-१५ सेमिको आट (प्रोजेक्सन), यसको मोटाई जम्मकाठको आट (प्रोजेक्सन) को मोटाईमध्येत कम हुनेदैन।
• जगामो ढलनको तहले पर्वतलोक पुटिड राखनको लागि समतल सतह बनाउँछ, ढलना बनेका खाल्कुड़ी मिलाउँछ र जमिनको नर्म सतहबस्तलाई भन्ने काम गाउँछ।
• भार धेरै थामुने ४ भने र जमिनको भारबन्ध वक्षमा कम ४ भने डेंड्री राखेको पुटिड गर्न सकिन्छ। यसलो अवस्थामा डेंड्री सहितको ढलनको पुटिड राखिने भने व्यापक पारापुर्बमा हुनु चुनौती खर्चिलो।
• डेंड्री सहितको ढलनको पुटिड तल ७-८ सेमिको पालि ढलनको तह अनिवार्य बनाउनुपर्न।
फुटिडका प्रकार

काठ/सोसाको खम्भाको फुटिड
कैटिट/ईटाको खम्भाको फुटिड
डन्दी सहितको ढलानको खम्बा

1. ढलानको मिश्रणमा "सिमेंट, बालुवा र गिटी" को अनुपात सामान्यतया "1:2.5" अथवा "1:2:4" हुनुपर्छ।
2. फलमाध्यम डन्दी सहितको ढलान बनाउन्छ तलका मध्ये कुनै एक खालको डन्दी प्रयोग गर्न सकिन्छ : क) माइल्ड रिल र टोलरिल डन्दी ख) उच्च क्षमताको लिम्बियन्फ डन्दी।
3. फलको डन्दीमा खिदा, रह, भेल, माटो लगायतका डन्दीलाई हाति गर्न सकिन्छ वा त्सलाई ढलानसेंग जोडिन नन्दिने कुनै पनि पदार्थ लगाएको हुनुपर्छ।
4. फलमाध्यम धारावट डन्दीलाई 8 इंच (200 मिलिमिटर) को रिर्क (2.5) ले बोञ्चनु। दुईहाट रिद्वोचको दूसरी सामान्यतया 8-10 इंचमा बढी हुनुपर्छ।
5. वर्गालाई पिलर कर्तिकको "सेंटि" 30x30 सेंटिमिटर (12x12 इंच) का हुनुपर्छ। दुईहाट पिलरबीचको दूसरी 4.5 मिटर (14 फिट 9 इंच) भन्दा बढी हुनुपर्छ।
6. खालील, छान र जगालाई एकाप्रथम जोडिको मजबूत पाने डन्दी राखेको ढलानको प्रैम (चोको) बनाउनुपर्छ र ढलान छाना 4 मन त्सले पनि प्रैमको काम गर्न सकिन्छ।
7. इन्जनियरिङका या अन्य पवेलिङ नम्बरका खुला ठाउँमा ढलानको ब्लाइंड (लिन्टर) राख्ने गर्नुपर्छ।

रिमिटको भाग देखिने नक्सा (आइसोमेट्रिक)

पिलरलाई शीर्ष काठिन्दा देखिने नक्सा (प्लान)

पिलरलाई शीर्ष काठिन्दा देखिने नक्सा (सेक्सन)

फलमाध्यम रिर्क
12 मिलिमिटर अथवा 16 मिलिमिटरको डन्दी
भार वहन गर्ने मित्ता

माइल्ड रिटर्न डल्ली, हुप आइरन तथा फलामे जलीको प्रयोग गर्ने गरोलाई बलियो बनाउन सकिन्छ र यसले श्य भार वहन गर्नुका साथै भूकम्पसार र हावाको चायबाट आउने घरका तथ्यम गर्ने सक्छ।

झ्यालोका र दुईबटा पखाल नजोड़िएको लामो पखाल बनाउँदा यदि होलोर्क लगाउने भए हरेक १.२ मिटरको अंतरमा र सोलिड इंटा लगाउने भए हरेक २ मिटरको अंतरमा डल्ली राख्ने बलानको लागि हल्नुपर्छ।

डल्लीमा दिनेको नलानगर भन्नका लागि डल्लीको वरियो हुलीमा १५-२५ सेमिको बलान (कमार) ले छोर्नुपर्छ।

इंटाको पिरुर र भुईको स्थायलाई पनि डल्ली राख्ने श्य बलियो गर्नुपर्छ।

पखालका लागि समेत जगमा बलान हुनुपर्छ। इंटाको पखाल (गारे) लगाउँदा जगमा डल्ली सहितको बलान गरी गारेको हरेक जुना र पछिल्लो डल्लीलाई खुदा गरी लगाउँनुका साथै झ्यालोका आदिको कुन्नमा पनि डल्ली राख्नुपर्छ। यसले गारो लगाउँदा डल्लीलाई १.२ मिटरको दूरी नब्बाई राख्नुपर्छ।
ಡನ್ನಿ ಪ್ರಯೋಗ ಗರೆಯನ್ನು ಪರಾಳ

ಪರಾಳಕು ಪರಾಳಕು ಸಬ್ಬಲು ರೂಪಿ ರಿಂದ ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನ ಜಾತಿಕೆಯಾಗಿ ವಿಶೇಷವಾಗಿ ಸಬ್ಬಲು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುವ ಇನ್ನು ಪರಾಳಕು ಜಾತಿಕೆಯನ್ನು ತನ್ನಿಗಾಗಿ ಬೆಳೆಯುತ್ತದೆ.
काठको फ्रेम

काठको घरमा चारै कुनाको काठको खम्बालाई इयाल्मुनिको भाग, इयाल्माधिको भाग र पर्वतालाई राखिने दोटलो बीडिको हुनु । बृक्षै र हावाको घरका धान्य सके बनाउन सबै कुनाको विभिन्न केसर बलियो बनाइएको हुनु । यस्ता घरको पट्टाल (मिता) बौँस, पटेर वा काठ जसला हल्का सामग्रीले बनेको हुनु ।

1. इयालको तलको भाग ४०५९० मिलिमिटर, १०५९० मिलिमिटर अथवा लोभर्दा दुई हुनुछ । इयालको तलको भागलाई दुईविश्वास एकटे बोल्टले जमासंग जोडेको हुनु । यस्तो बोल्टको गोलाई १२ मिलिमिटर र लम्बाई ३५० मिलिमिटर हुनुछ । जोडिने दुईविश्वास एकटे बोल्ट रहनुछ । दुईविश्वास बोल्टबिधिको अधिकतम दूरी २ मिटर मात्र हुनुछ ।

2. फ्रेमको नेपाली नाथ ४०५९० मिलिमिटर हुनुछ । दुईविश्वास फ्रेमबिधिको अधिकतम दूरी ०.५ देखि १ मिटर मात्र हुनुछ । यदि फ्रेम ४०५९० को छ भने दुईविश्वास फ्रेमबिधिको दूरी ०.५ मिटर मात्र हुनुछ । यदि फ्रेम १०५९० को छ भने दुईविश्वास फ्रेमबिधिको दुरुलाई दोभर पान सकिन तर यसले गर्दा मित्री र बाहिरी लाइफनिक गोटो बनाउनु पनि हुन सक्छ ।

3. यस्ता घरको तलको उचाई २९ मिटर (५ फिट ९ इंच) भन्दा बढी हुनुहुनेछ । दुईविश्वास घरका लागि हरेक ०.५ मिटरमा फ्रेम स्थापनाहुनुछ ।

4. फ्रेमको सਲिमन्द्र माधिको भागलाई टप पट्टेसंग जोडेको हुनुछ । टप पट्टाको नाथ फ्रेमको नेपाली नाथ हुनुहुनेछ ।

5. भिव फ्रेमबिधमा भएका इयाल्मुनिको भाग, फ्रेम र इयाल्माधिको प्लेट एकाप्तमा कुनामा कैन्दी जसलो पाएको जोडिएका यहाँ तिन्न लगान सक्छ । फलेकले बीडिको छैन भने सबै फ्रेमलाई कमली १५ मिटरको उचाईमा त्यसै फ्रेमले जोडेको हुनुछ ।
04 छानो : आधारभूत सिद्धान्त

हावाको गति अनुसारका छानाको प्रकार

1. 30-40 डिग्री मिरालो छानोले चाप उतपन्न हुने छ छानो उडाउने जोखिम घटाउछ।
2. वुल्फिमा पवित्र नमएको छानो। वुल्फिमा पवित्र ल्गाउने हो भने त्यसको छेउलाई घरको पवित्रिसेंग राइसी जोड्नु पर्दछ। एकत्रित छाना सक्नुहुन्छ।
3. छानो पवित्रलाई 2 फिट 6 इन्चमुञ्दा बर्दी बाहिर निकाल्नुहुन्छ।
4. झुलान गरिएको छानोले थेरी रासमोसेंग छुप्ना दिन्छ तर त्यसलाई पानि खाला बढ्दै राखेको पवित्रिसेंग राइसी जोड्नु पर्दछ।

छानोलाई घरको पवित्रीसेंग जोड्ने तरिका

1. डोडहरु तोकिएको दूरीमा रख्नु पर्दछ।
2. छानाको पाखालाई छुडको फैमले बीकोत्नु पर्दछ।
3. छानोलाई पवित्रिसेंग मज्जुत पार्ले जोड्नु पर्दछ। यसका लागि चलामा पाता राखी सामान्य कीलाई होइन दुवेटिर वासर मएको बोल्टले कम्नु पर्दछ।

छानोलाई सही तरिका

1. टाययल ल्गाउने हो भने हरेक टाययल बीकोत्नो हुनु पर्दछ। जसलाई ल्गाउने हो भने त्यसका हिलामा कीला टोक्नु पर्दछ।
2. यसका लागि अंग्रेजी जे आकारको हुकbolett अथवा स्कु (गुणन) मएको अथवा टिक्सेड कीला प्रयोग गर्नु पर्दछ।

नियमित मर्मत

1. छानाको विशेषणको धूरी र कुनाको नियमित जीवन गर्नु पर्दछ।
2. बोल्ट र काठ कमजोर भएका वा खुलकन लागेका छन्नु भने तिनलाई हटाउन नयाँ रख्नु पर्दछ।
3. जसलाई ल्गाउने हुक या कीलालाई हावाको घरको स्थान सक्ने बनाउन समय समयमा कम्नु पर्दछ।

छानाको आकार

चुफ्फीमा पवित्र नमएको (hipped roof)

चुफ्फीमा पवित्र भएको (gable roof)

एक पाखे छानो (lean-to-roof)
काठको फ्रेमको बनावट

छानो पर्याप्त मिलालो भएको (२५ डिग्रीमा बढी) बनाउँदा यसले छानोलाई हामाः धेरै जोखिम घटाउँछ र छानामा परेको धृष्टि पनि रामरोसंग तरिका राखिन्।

1. छानो पर्याप्त बढीमा ६०० एमएम. मात्र निस्को छुनुपर्छ।
2. छानामा प्रयोग हुने काठ साल, साज जस्ता कधा काठ छुनुपर्छ। यसलाई उपयुक्त रसायनले उपचार (treatment) गरेको छुनुपर्छ।
3. छानामा लगाइएका सबै काठ एक अर्कोमा रामरोसंग जोडिएको हुनुपर्छ। भाटालाई डोकासंग, डोकालाई पर्याप्त वालफेलाई अनि वालफेलाई सवारी जोडिनुपर्छ।
4. पातका कोरोमेंसनको हिल्मा (उठेको भाग) 'जो हुक अथवा दिर्वाकिने भाटासंग जोडिनुपर्छ। हामाः छानो उठाउन नपाआस भनाका लागि छानाका छेउँढ़ि आँख बालोसंग जोडिनुपर्छ।

- हरेक ९० सेमि.मा ढोका
- हरेक ७० सेमि.मा भाटा
- धुरीको वारपार जोडिनेको काठ
- हरेक ४५ सेमि.मा थप भाटा
चुच्ची भएको छानो

पर्वतमा बाहिर निर्मको छानको अधिकतम भाग (६० सेमि)

दुईवटा खम्मारीसँग अधिकतम दूरी ३ मिटर

उत्तमको छूई स्थाप
ञापाखे छानो

अनकरत (ञापाखे) दूरी

भाटा

डोंडा

थप भाटा

दुईवटा खामबीचको अधिकतम दूरी ३ मिटर

ढलानको भुई रंगाब
फलामे संरचना

जस्तापाला

मूल खाँबो

फलामे एंगल

ढोंगा

छानालाई तेसों
जोड्ने बिम

बर्सातको पानी
बन्ने ढुँढ

ढुँढ कर्ने फलामे
ब्याकेट